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ADHESIVES AGE

MANUFACTURE, APPLICATION, TECHNOLOGY, RESEARCH AND MARKETING

NUARY, 1959

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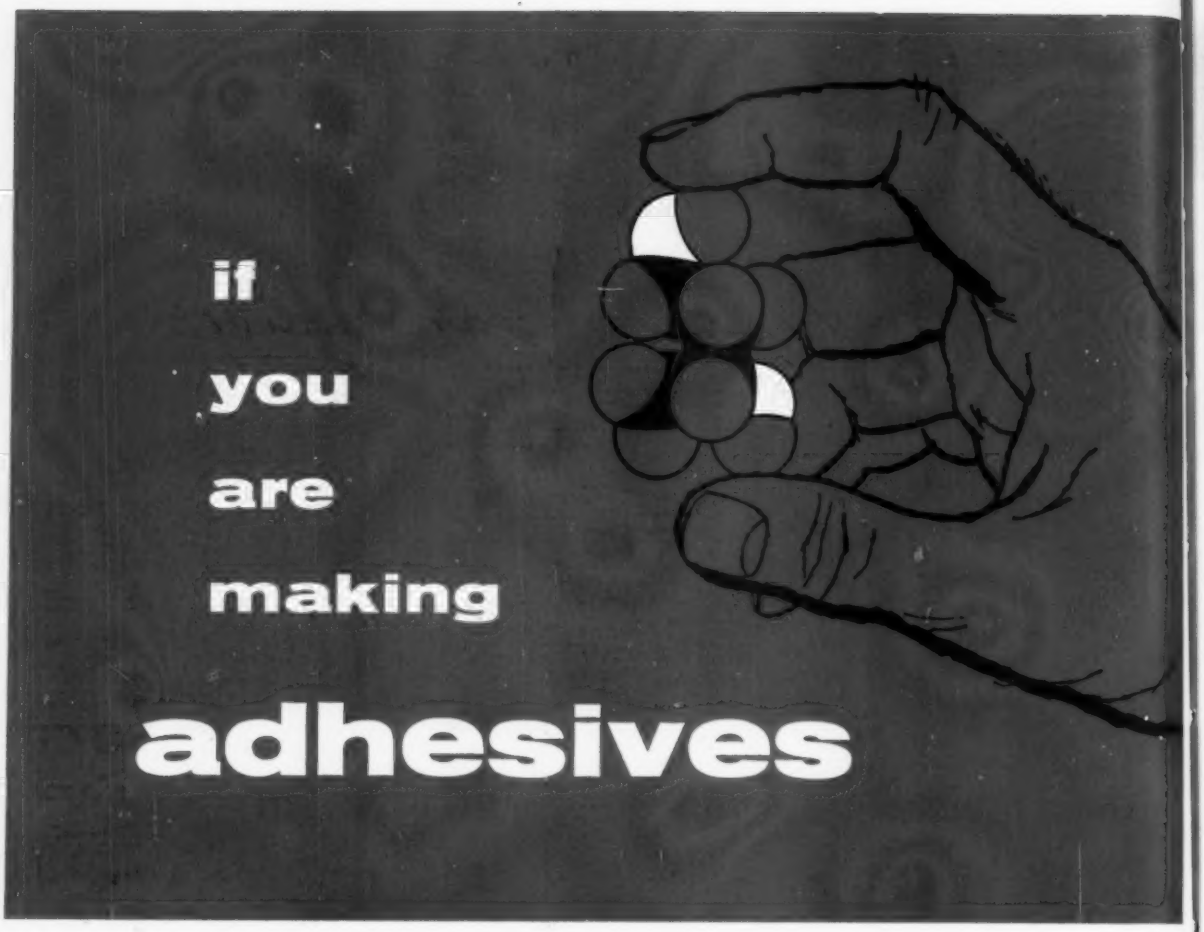

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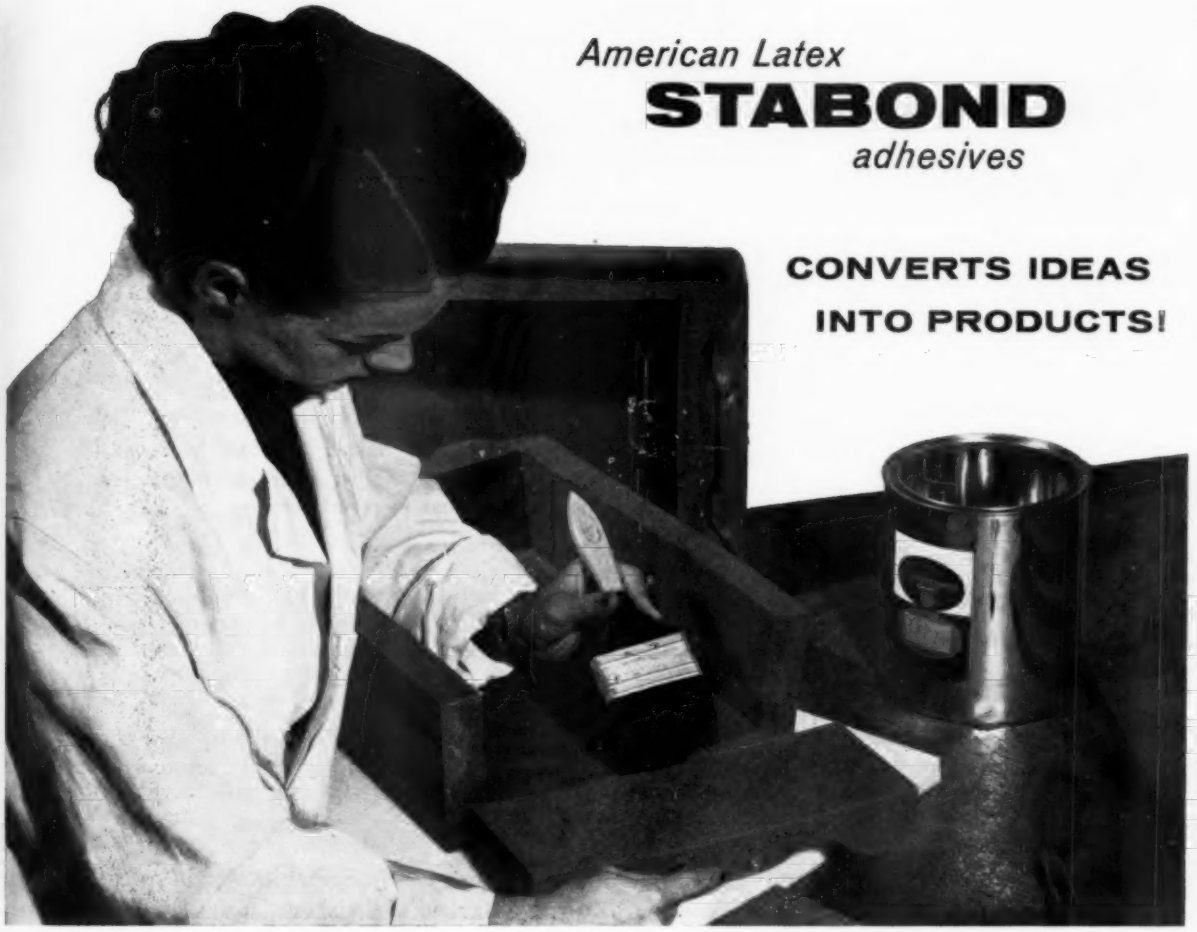

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ADHESIVES AGE

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Typical application of polyvinyl acetate emulsion adhesives requires the agitation of the compound by a portable mixer. Photograph courtesy of the Dewey & Almy Division, W. R. Grace & Co., Cambridge, Mass.

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PALMERTON PUBLISHING CO., INC.

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Indexed in Industrial Arts Index and Engineering Index.

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10,500 Copies of This Issue Printed

ADHESIVES AGE is published monthly by the Palmerton Publishing Co., Inc. Printing Office, Bristol, Conn. Editorial and Advertising Offices at 101 West 31st Street, New York 1, N.Y. Subscription in the United States, $5.00 a year; Canada, $5.50; Foreign $6.00. January, 1959. Volume 2, Number 1.

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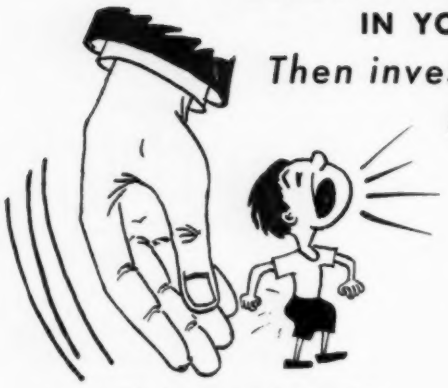

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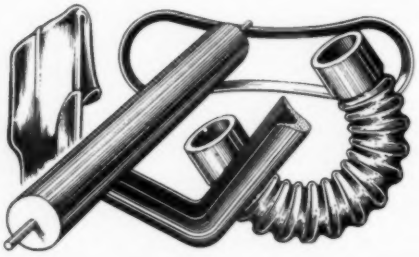

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Published Monthly by
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Editorial and Advertising Offices
101 West 31st St., New York 1, N. Y.
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EDITORIAL

The experience of American industry has proved time and again the value of standards. It is no longer necessary to "sell" standards as such. All industry, from manufacturer to user, is served when standards are established. They help in that minimum requirements are defined, testing procedures are certified, common language is developed and confidence of the customer is established and held. Great convenience for the user is added. Money is saved by all concerned. The ultimate inherent value of giving the consumer a feeling of reliability cannot be underestimated.

Every purchasing agent knows the value of standardization. He looks upon it as his greatest money saver. He knows that a standard product costs less than a "special." Competitive products can be compared. Standards reduce inventory size and inventory costs. Accurate standards make it unnecessary to include costly "safety factors" in purchasing specifications.

The chemical industry is working hard on the matter of standards. This industry has yet to achieve the complete standardization which is so desirable and which is the goal of the work and investment. However, there is definite work being done. The chemical industry could have saved up to $20,000,000 last year if it had had adequate uniform standards available for most of the things it bought. On the other hand, the petroleum industry has achieved a high level of standardization. Oil men buy almost everything they need according to recognized standards.

The adhesives industry is in a peculiar position where standards are concerned. Despite the availability of a number of recommended and approved ASTM standards, few manufacturers use the same tests and specifications. Large users of industrial adhesives pay little attention to these tests and specifications. Committee D-14 on Adhesives is doing an excellent job where standards themselves are concerned, but obviously a good deal of education is required before buyer and seller adopt them on a universal basis.

Although ASTM has laid down standards for strength tests, much additional work is required along these lines. No acceptable standard exists for tack values or for viscosity, the problem in the latter case being attributed to the wide variety of viscometers used to determine viscosity and the lack of correlation among and between these instruments. There are many other testing avenues down which adhesive technologists must go before standards are developed and adopted for the ever-increasing types of adhesives commercially available.

It is unfortunate that industry is not making greater use of the standards on adhesives which are currently available. We admit that the adhesives industry is not in complete agreement with the terms and regulations laid down in these standards, but if manufacturer or user finds any particular objection we urge that he become more familiar with the aims and objectives of the American Society for Testing Materials. Committee D-14 welcomes with open arms representatives of all companies which have a special interest in the field of adhesives and offers a perfect arena in which to throw open to debate any questions pertaining to standards, specifications and/or tests.

There is no argument with the fact that industrial standards benefit both manufacturer and user. Further standardization in the adhesives industry is a must.

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CONSULTANT'S CORNER

By Dr. Irving Skeist

Aluminum Foil to Asphalt Saturated Felt

Question: "For some time now, we have been attempting to bond 0.004 inch aluminum foil to asphalt saturated roofing felt, with little success. Since the product we have in mind would be used as a roofing material, the bond must be satisfactory over a temperature range of —40°F. to 160°F. The materials we have investigated thus far do not have satisfactory adhesion at depressed temperatures. Can you recommend a satisfactory material?"

Answer: This is a typical problem in which the selection of an adhesive is made difficult because of conflicting requirements. Two separate challenges face the adhesive formulator: the wide temperature range and the great disparity in chemical characteristics of the materials being bonded. In general, polar adhesives such as polyvinyl acetate and casein have fairly good resistance to elevated temperatures and adhesion to aluminum, while rubbery materials have the best low temperature properties and adhesion to asphalt. A working agreement must be reached between polar and non-polar, hydrophile and hydrophobe, metal and hydrocarbon.

One possible compromise is a casein-neoprene latex. The proportion of casein would have to be determined experimentally to give enough heat resistance without embrittling the bond at low temperatures. The latex might contain approximately 35 per cent solids. Since both adherends are impervious to water, the adhesive should be applied to the foil and the water evaporated before the felt is composited with the aluminum.

Polyethylene might provide an even better solution. It is flexible at well below —40°F., and does not melt until well above 160°F. The preferred technique involves an extruder-laminator. The polyethylene is extruded through a narrow slit die. Within a few inches of the orifice, while the plastic film is still hot, it is laminated to the aluminum foil. The asphalt felt could be bonded at the same time or subsequently.

In view of its low cost, asphalt itself is worth investigating as the adhesive base. Improved low temperature flexibility and adhesion to aluminum might be provided by suitable compounding with other ingredients. Many formulations suggest themselves as worth trying.

CONSULTANT'S CORNER

Flame Resistance

Question: "Can you suggest a flame-proof adhesive for the flocking of fabrics?"

Answer: Adhesives vary in combustibility all the way from nitrocellulose, which flares violently, to the silicates, which do not burn at all. These latter are too alkaline and too stiff for most textile applications. Practically, the vinyl chloride resins are probably the best choice. Polyvinyl chloride and vinyl chloride copolymers melt and burn while in a flame, but do not support combustion when the flame is withdrawn.

The flammability of vinyl compositions depends to a considerable extent upon ingredients used in conjunction with the resin. The vinyls can be applied as latices, lacquers, organosols or plastisols. Lacquers and organosols contain combustible organic solvents; but these are not present in the finished product, as they are removed by evaporation. Of the non-volatile components, the plasticizers are the most likely foci of flame sensitivity. The phosphate primary plasticizers and the chlorinated hydrocarbon secondary plasticizers should be given preference over other types, if this is feasible, as they will add to fire retardancy.

Plastisols are 100 per cent non-volatile dispersions of vinyl chloride resins in liquid plasticizers. Since there are no volatiles, there is no problem of low flash temperature during application. On the other hand, the choice of plasticizer is restricted to combinations having good viscosity aging characteristics; this unfortunately tends to exclude the aryl phosphate plasticizers.

Flame resistance of vinyl chloride adhesives as well as other resin types can be improved through the addition of suitable pigments. A favorite flame retarder is antimony oxide, a white pigment, employed in 5 to 10 per cent concentration.

Melamine to Thermoplastic

Question: "In designing a new product, we have the problem of cementing a melamine surface and a plastic extrusion. The thermoplastic extrusion will be of butyrate, styrene, polyethylene or rigid vinyl, with final selection probably dependent on choice of adhesive."

Answer: The problem of cementing two different plastic materials is inherently a difficult one, and is not simplified by the fact that a thermosetting material is to be combined with a thermoplastic. The four thermoplastics mentioned are quite distinct in ease of bonding, solubility, hardness, stiffness, polarity and other characteristics of interest to formulators.

Experimental work would be required to determine the best combination and find an adhesive. The design may aid or hinder bonding. My guess is that butyrate or rigid vinyl will be more amenable than styrene or polyethylene. An epoxy adhesive may do the trick, provided it is properly formulated.

Dr. Skeist, visiting professor of Physical Chemistry of Polymers at Stevens Institute of Technology, is associated with Skeist & Schwarz Laboratories, Inc., 89 Lincoln Park, Newark, N. J.

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Dry Bonding Adhesive

Heatweld is a new dry bonding adhesive for cementing fabric, leather, paper, plastic and other materials. After application to the material, the adhesive is allowed to dry and bond is formed by applying heat. Once a surface has been coated, the actual bond may be made at any time. Transparent, nonstaining, and resistant to both washing and dry cleaning, Heatweld can be applied by brush, roller, spray or conventional coating machine. It is nonflammable and does not require heating before being applied. Suggested uses include: adhering emblems, embroidery, and zippers to garments; covering books, table tops; manufacture of leather goods. *Adhesive Products Corp.* P-41

Time Autoclave Labels

Adhesive and vinyl coated Time Autoclave Labels are unique in that the word "sterile" is invisible at room temperatures. Only when subjected to a complete autoclave sterilization cycle does the heat sensitive ink allow "sterile" to appear automatically. *Professional Tape Co.* P-42

Self-Adhering Cord-Mount

An extruded plastic channel designed as a receptacle for all loose extension or appliance cords, Cord-Mount has a pressure sensitive adhesive backing that bonds instantly to any clean, smooth, dry surface. Fireproof and impervious to humidity and normal temperatures, it resists all alkalies and acids. It is also available with a permanent adhesive laminated on the back which will permit a permanent bond to difficult surface types such as brick, concrete, and raw rough-surfaced metals. *Hoff & Lund Mfg. Co.* P-43

Clean-Up Detergent

Uncured epoxy, polyester and similar resins may be efficiently removed with Isoterge 1401, a solvent-based clean-up detergent. Designed for operations where safety is a must, this cleaning material is nonflammable and of minimal toxicity. Waste resins are converted into a completely water dispersible state. After excess resin has been cleaned off with a scraper, a cloth saturated with the detergent will clean up the rest. *Isochem Resins Corp.* P-44

Ceramic Tile Adhesive

Ceramic tile may be installed over gypsum wallboard, finish coat plaster, painted plaster, concrete or almost any sound smooth surface with CTA-50. Water-base adhesive eliminates solvent odor and minimizes fire hazard. Trowels on smoothly and easily without stringing or becoming

gummy. It is said to combine water resistance with unusually high bond strength. One pound of adhesive will do the job of nearly 40 pounds of wet mortar. The final dry weight of an adhesive bonded tile wall section will be about half the weight of a section installed with mortar. *Adhesives, Coatings and Sealers Division, Minnesota Mining & Mfg. Co.* P-45

Epoxy Stick Adhesive

Formed from solid epoxy resins, Epistik can be used for bonding any material that can withstand curing temperatures of 260°F. or more. The manufacturer states that the tensile shear strengths of joints made from epoxy sticks are among the highest obtainable and that in pure tension the joints proved significantly stronger than any paste or liquid formulation tested. It is especially recommended for bonding ceramics, carbides, graphite, asbestos, etc. to metals and for bonding all types of metals to each other. Parts to be joined are warmed to about 225°F. and the stick rubbed over them leaving a thin coating of adhesive. Coated parts are immediately placed together for curing. They may, however, be allowed to cool and then reheated for curing at any time. *Robert Marks Co.* P-46

Liquid Cement

In cementing wood or porous materials with Ambroid Liquid Cement, 25 per cent of ultimate strength is said to result in two hours and total ultimate strength in 24 hours at room temperature. The nitrocellulose base product dries entirely by evaporation of the solvent. When used in making wood joints, tensile strength of from 400 to 500 pounds per square inch resistance to shear is developed. Joints are permanent unless subjected to temperatures above 180°F. for considerable periods of time. The film is water, gasoline, model fuel and oil resistant. This transparent amber cement contains no material generally considered toxic. Features include good impact and vibration resistance and high dielectric qualities. *Ambroid Co.* P-47

Solution Adhesive

The advantages of a two-part curing system without the disadvantages of a high temperature cure are said to be available with a recently announced solution adhesive. ARCCO C 520 and Accelerator C 520-1 cure at room temperature and provide strong bonds between a wide variety of materials such as neoprene, wood, leather, cork, paper, cloth, asbestos board, masonite and surface treated metals. Cold bonding type of adhesive eliminates expensive cures and makes possible application to many surfaces where heat would be objectionable. *Chemical Division, The Borden Co.* P-48

Maraset 532 Adhesive

A new general purpose adhesive, Maraset 532, has been developed primarily for joining metals to metals, although it has also shown good and combinations of materials including glass, plastics, wood and masonry. When reinforced with fibrous glass cloth, it can be used to repair tanks and vessels. The new adhesive is a two-component epoxy which has good resistance to water, chemicals and solvents. Used in a thin layer, it bonds under only contact pressure, resisting delamination well. For general use, Maraset 532 is blended

with a hardener and cured overnight at room temperature or for one hour at 200°F. Aluminum-to-aluminum bonds of the new adhesive have shown tensile shear strength of 2,000 psi after room temperature cure, and 3,800 psi after a one hour heat cure. In a liquid hydrocarbon, the strength fell to 3,300 psi, and in JP-4 jet fuel to 3,100 psi. *Marblette Corp.* **P-49**

Concrete Patch Kit

Epocrete is a two-part concrete patch kit for maintenance and repair of floors, driveways and masonry. The epoxy-based concrete cures at room temperature with practically no shrinkage. It is said to have twice the compressive strength of concrete and three times its abrasive resistance. Adhesion to steel, concrete and wood is more than 1000 psi. It can be feathered to a fine edge without crumbling. Kits of one quart, four quarts and four gallons consist of a pre-mixed aggregate and resin, and a pre-mixed aggregate and hardener. *H. V. Hardman Co., Inc.* **P-50**

Drill Bushings Bondant

Drill bushings installed with B-K No. 7 Cement are said to resist equal or greater pushout loads than press fit bushings. Simple application requires no trained personnel. After drilled hole and bushing are cleaned with acetone, carbon tetrachloride, or a similar grease solvent, equal parts of the cement and catalyst are mixed on a piece of paper and a coat applied to the bushing and drilled hole. The bushing is then inserted on a precision pin engaged in the "master jig" and the cement allowed to set for 12 hours. The bondant is acid, fungus, salt and heat resistant. A 250-watt infra-red lamp accelerates curing time to 40 minutes. Larger mixes safely made if container is chilled in ice water. *Sheridan Products Inc.* **P-51**

Labeling Adhesive

Paper labels can be bonded to fiberboard, wood, steel and galvanized iron with EC-1341, a newly developed synthetic resin base, transparent adhesive. After bonding, another coat of the adhesive over the label insures maximum protection against abrasion, marring and corrosion. Application is by brush. *Adhesives, Coatings and Sealers Div., Minnesota Mining & Mfg. Co.* **P-52**

Eccobond Preform Adhesive

Eccobond SBC is a single part epoxy adhesive which can be molded readily into a preform. The material is supplied in powder form, heated slightly, molded under moderate pressure, and then allowed to cool. The resultant preforms are then usable as a quick setting adhesive for numerous jobs such as bonding anode caps to vacuum tubes, cementing tube bases, or any job where an easy to handle, rigid preform simplifies the operation. Complete cure of the preform is completed in a few minutes at temperatures ranging from 350 to 500°F. *Emerson & Cuming.* **P-53**

Elastomeric Base Laminate

Neither heat nor pressure is needed to provide high strength bonds between a variety of materials laminated with EC-1368, a new elastomeric base adhesive. Bonds produced are said to have exceptionally

high dead load shear strength, peel strength and excellent resistance to cold flow. The water resistant adhesive will retain strength and adhesion at temperatures over 200°F. Uses include bonding decorative plastic laminates to metal surfaces and non-load-bearing sandwich panel construction in which plastic, steel or aluminum facings are bonded to paper honeycomb cores. Bonds between high pressure laminates and steel, aluminum or wood have shear strengths in the range of 500 psi; bonds of wood to wood develop shear strengths up to 300 psi after aging five days at room temperature. Application is by brush, spray or hand roller. *Adhesives, Coatings and Sealers Division, Minnesota Mining & Mfg. Co.* **P-54**

Cold Polishing Glue

Manufactured in several grades, Rediglu is a cold glue designed to meet various polishing problems. Its use is said to eliminate wheel glaze on fine grain grinding, or frequent resurfacing with coarse grain. No heating is required. The glue is packed in one gallon and 70-lb. pails. Rediglu Thinner is packed in one and five gallon pails with convenient pour spouts. *Redi-Products Co.* **P-55**

Columbia Carpet Kwikstik

"Columbia Carpet Kwikstik," an extremely fast-drying and setting carpet seaming adhesive, has been introduced to the carpet trade. The non-flammable product is white in the liquid state, drying to a transparent, waterproof, high-strength bond. Carpet Kwikstik is reported to be an ideal product for carpet seaming, edge binding, anti-skid backing, anchoring tufts and general carpet and fabric repair work. According to the company, extensive tests in carpet workrooms have proven that Carpet Kwikstik provides the best coverage and most rapid drying properties—at the most economical price level in the industry. *Columbia Cement Co.* **P-56**

Honeycomb Sandwich Adhesive

Designated as Scotch-Weld Brand Bonding Films AF-200 and AF-201, two new composite film adhesives are said to reduce production costs for high strength sandwich panel construction. They consist of a high strength elastomeric adhesive film on one surface and a self-filleting adhesive film on the other. The elastomeric adhesive bonds to the facing, and the self-filleting adhesive bonds to the core of the honeycomb sandwich panel. The highest combination of peel strength and beam shear strength is said to be provided at service temperatures ranging from —70°F. to 250°F. Because of high performance level obtainable, less adhesive is necessary to effect a good bond and the resultant panel weighs less.

Supported composite film adhesives eliminate the need for sandwich core priming. The absence of solvent eliminates waste, shrinkage and drying problems. Resultant advantages include clean bonding operations and simple application procedures. *Adhesives, Coatings and Sealers Division, Minnesota Mining & Mfg. Co.* **P-57**

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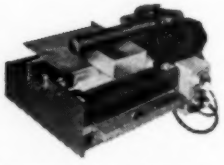

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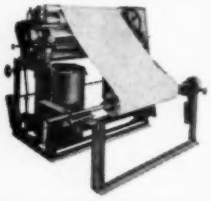

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THE BUSINESS OUTLOOK FOR 1959 has now taken fairly firm shape in the thinking of economists in government and industry. In a nutshell, experts see 1959 as one of the best years ever, with the current recovery rolling on to new highs, month after month. Sales and output will set new records, and rising productivity will lift profits sharply. Consumers will share in the benefits, too. Incomes will rise smartly while living costs remain stable.

THERE IS STILL SOME DOUBT ABOUT THE DEGREE OF BOOM that is coming. The expansion will be rapid—almost explosive—in the first six months of 1959, but there may be some slowdown in the growth rate in the second half. Much depends on what happens in autos, housing, and outlays for new plant. But businessmen can count on the government to keep the climate favorable. Credit won't be tightened enough to curb the recovery—except, perhaps, in the case of housing. And, despite the deficit, taxes won't be increased.

Here is what you can expect to see in three important areas:

- Governments at all levels plan to increase outlays by about $8 billion—and maybe more. Local governments will expend $3 billion more for schools, waterworks, etc. The U.S. will hike outlays $5 billion for defense, highways, and farm aid.
- Consumers will be buying $15 to $20 billion more, encouraged by rising incomes. Hard-good sales will increase 15%, autos setting the pace. Food, apparel, and services will rise, too.
- Business itself will spend much more on plant and equipment. And industry will start building inventory at a rapid clip.

THE ECONOMY WILL GROW A THUMPING 8% IN 1959, measuring in terms of Gross National Product—total output of goods and services. This will lift GNP to $475 billion for the year. This compares with the $440 billion total of 1958. The last quarter of '59 may see a still higher rate—$485 billion.

Other key business indicators will look like this in 1959:

- Industrial output will be up 8%, to 145% of the 1947-49 rate.
- Number employed will gain about 1.5 million, with those big jumps in factory output coming from rising productivity.
- Unemployment will go down about 1.2 million on the average. Labor force growth, plus productivity, explain the slowness.
- Housing starts will rise to 1.2 million, 5% to 6% over 1958.

PRICES WILL INCREASE ONLY MODERATELY, on the average, during 1959. The official Consumer Price Index will increase by 1% or even less. Services—rents, utilities, etc.—will be higher, as will manufactured goods such as appliances, autos, building materials, etc. But food will fall a bit in early 1959. Wholesale prices will rise 2%, with industrial items setting the pace.

capitol cues

THE COST OF LABOR WILL RISE FASTER IN 1959 than in the year now ending. Manufacturing industries will see costs go up 9¢ to 10¢ an hour. This year, wage increases averaged 1¢ less; the business recession held boosts down. In nonmanufacturing hikes will run 11¢ an hour in 1959, as against 10¢ this year.

Increases in straight hourly wages will account for about 8¢ of the 1959 increase as against 6½¢ this year; unions want to make up for ground lost in the slump. Escalator clauses will bring the other 2¢. Fringe benefits will play a minor role. Unions will try mainly to bolster their existing benefits.

PROFITS ARE CERTAIN TO BE TERRIFIC NEXT YEAR. With industry's output expanding, productivity will go up faster than costs. The net before taxes may go as high as $48 billion, as compared with this year's $37 billion. The best year on record, so far, was 1956, when the total reached $45.5 billion.

CREDIT SEEMS LIKELY TO TIGHTEN STILL FURTHER, as was noted above. Money will be harder to find and interest rates will rise some more. Demand for credit will expand as industry starts to build inventory and to increase plant outlays. The government also will need more cash to pay its deficits.

The supply of money will increase some as corporate profits and savings rise. But it won't meet all demand. Monetary officials will keep the reins taut to curb inflation. Mortgage borrowers will feel the pinch the most; consumer credit will be plentiful.

ANOTHER RECORD CONSTRUCTION YEAR is in sight for 1959. Dollar outlays will go up about 7%, to $52 billion. Price increases for labor and materials will account for 2% or 3% of the boost. Tight money will hinder housing some.

- Public outlays will jump 14%, more than twice the rise this year. Experts think public housing will rise 36%; highways, 12%; schools, 4%. Post offices and hospitals will gain, too.
- Private spending will be up 3% next year, as against a dip of 1% this year. Home-building will rise a little more, as will commercial work. Industrial and utility building will fall.

Next year will see pick-ups for building materials producers. Cement sales will rise 5% or 6%, those of clay products will be up 3%, while volume in paints and lumber will gain 4%-6%.

THE 1959 PICTURE FOR MACHINERY IS SPOTTY, some types slated to do much better than others. Increases in spending for plant and equipment, plus the rising trend to automation, will help certain lines. Prices will rise 2-10%.

Here's the outlook, line by line, as the experts see it:

- Machine tools—Sales, off over 60% in 1958, should pick up 15% to 20% next year, on ordering from auto and appliance makers.
- Construction—Sales will climb 10%, to $1.8 billion. (In '58, volume matched 1957's.) Rising road-building is a key factor.
- Office—With modernization expanding, sales will rise 10-12%.
- Other types—There will be nice gains for oilfield, railroad, and materials-handling-equipment, and textile machinery. But, some decreases are being forecast for 1959 for mining types.

on the continent

by FELIX F. FLUSS

• Geigy Co., England, has reduced prices of tri-xylyl-phosphate (TXP), which now sells for less than tritolyl-phosphate (TTP), the other important phosphate plasticizer for polyvinyl chloride plastics. Prices of sebacic acid and diester and polyester plasticizers, manufactured from sebacic acid, have also been lowered.

• Cory Brothers, England, has organized, through its Portuguese subsidiary and in cooperation with Reichhold, Hamburg, a new company to be called "Resintela Resinas Sinteticas Limitada." A modern plant is being built on the outskirts of Lisbon, which will start producing a number of Reichhold resins in the near future.

The first factory to manufacture synthetic resins in Portugal, the facility will fill the demands created by the rapid development of that country. Consumption of synthetic resins has been increasing at a rate of 20 per cent due to the expansion of existing industries and the appearance of new industries. Previously, resins had to be imported from the United States and Germany.

• Russian researchers have reported that sodium pentachloride phenolate is an effective antisepticum to be used to prevent the formation of mildew on glues. It is claimed that comparative tests have proved that tetra- and penta-chloride phenolates are better fungicides than beta naphtol. When humidity is increased, beta naphtol and trichloride phenolate lose their ability to prevent the formation of mildew. Penta-chloride phenolate is not affected by increased humidity. However, when adding tetra-chloride phenolate to heated animal glue, a very repugnant odor develops which causes severe headaches to the working force.

• The International Plastics Exhibition, which will take place from June 17 to 27, 1959, at the Olympia Palace in London, is expected to draw more participating manufacturers and visitors from many countries than any previous event. Another important exhibition will be the Third International Show, covering plastics and related fields, which will take place on October 19, 1959, in Duesseldorf, West Germany. About 400,000 square feet of display space will be available and more than 550 companies from eleven countries have booked space already. Over 300 companies will show processing of plastics. About 120 manufacturers of machinery and more than 70 manufacturers of plastics will be represented at this show.

During the preceding week, October 12 to 16, an International Round Table Conference, dealing with macro molecules will be held at Wiesbaden. An entire day, October 19, will be devoted to discussions of the aging of plastics and related materials. A special display, "Technical Progress through Plastics," will illustrate every important phase of the industry such as "Bearings without Lubrication," "Adhesives Instead of Rivets," "Compounded and Laminated Raw Materials" and others.

• The German building trade is eager to learn more about the Thin Bed Terrazzo Method developed in the United States, which is said to reduce the cost and labor of laying terrazzo floors. Terrazzo floors, known for their resistance to wear and tear, consist of a mixture of cement and marble chips, laid on top of an underbed. After hardening, the surface is ground and polished.

Last year, a new terrazzo topping, using either latex or a preparation based upon a special resin, manufactured by Monsanto and called "Lytron 682," was de-

About the Author . . .

► Felix F. Fluss studied mechanical engineering and chemistry at the "Technische Hochschule" and also graduated from the "World Trade Academy" in Vienna, Austria. He worked for several Austrian dailies and periodicals in an editorial capacity and afterwards organized his own business, publishing and editing a trade paper dealing with the gramaphone, amplifier and radio field. Other trade organs published by Mr. Fluss, covered the photographic, optical, chemical and shoe industries.

Mr. Fluss has traveled throughout Europe, visiting important industrial centers, calling on manufacturers and wholesalers, and attending conventions and trade fairs. He has taken annual trips to Germany, France, England, Switzerland, and other countries, in order to maintain contact with various industries covered by his business papers.

A United States citizen since 1944, Mr. Fluss was associated for a number of years with the mill supply and hardware field. About two years ago, he returned to his former activities and has been appointed American correspondent for 28 European trade papers. He has written several books, one of them, "Technology and Chemistry of Modern Shoe Repairing," is in the Library of Congress and the New York Library.

veloped. The new technique makes it possible to install large areas for as little as 50¢ per square foot and such floors can be mass produced in about one-fifteenth the time required to put in conventional terrazzo. Due to the lighter weight, latex and resin terrazzo compounds can be used to lay a new terrazzo floor over old wooden flooring without installing special reinforcements.

• Several new adhesives have been introduced abroad. A German adhesive called "Uhu" has had remarkable success in the United States and can be found in almost every American hardware and house furnishing store. In the United States, no money for publicity or advertising has been spent. It is only in view of the excellent quality of the product that it has gained such widespread distribution.

Retschitzka, a furniture cooperative in the USSR, uses a compound of viscous urea formaldehyde resin "M60" as a glue for plywood which can be applied cold or warm.

Russian research has developed an adhesive containing a casein base to glue paper bottles. The product consists of 1,280 grams of Casein (maximum water content 12 per cent), 120 grams sodium hydroxide, 480 grams rosin (maximum water content not more than 1 per cent) and 9,100 grams of water. The glue is used at a temperature ranging between 95°C. to 105°C.

• A French patent has been granted on an adhesive for gluing thermoplastic products which contains plasticizers. The adhesive is composed of a solution of polymeric compounds containing 60 to 80 per cent butadiene and 20 to 40 per cent acrylonitrile and a mixture of natural resins.

• A new method for the bonding of various materials which utilizes glues and mechanical fasteners, is described in a German patent. A filler and dimethylpolysiloxan, which is free from vulcanizing substances, will act as an excellent adhesive when used with nails, bolts, etc.

• India has introduced the metric system for weights and measures to be applied in the chemical, cotton, steel, machinery and paper making industries. Japan has also adopted the metric system, effective January 1. The system is not mandatory for the export business, but will be used extensively in dealings with foreign countries.

• Ruberoid Co., Hamburg, Germany, has introduced a new method for laying roofing papers. Each roll of paper has a strip of adhesive about six or eight inches wide on one side. In the application of the roofing paper, a special tool, resembling an electric iron and called "Rubomat," is used to heat the adhesive section which will stick to the wood or overlaying part of the next layer.

• A new crude oil refinery with a capacity of 2 million tons will be built in Maison-Carree, near Algiers, by a syndicate which consists of four French companies and the Standard Oil Co. of New Jersey. The American company has contributed 16.2 per cent of the capital.

• Rheinische Olefin Werke GmbH has built a factory for the production of epoxy resins, with a capacity of 2000 tons, near its polyethylene plant. Hitherto, epoxy resins, developed by Royal Dutch Shell, have been imported by Germany. German Shell, Inc., Hamburg, will sell the entire output, acting as general agent for the factory.

• Japan has started production of polyethylene at the Mitsui Petrochemical Co., Ltd. in Iwakuni. The plant has a capacity of 12,000 tons and uses the Ziegler low pressure process. The petrochemical plant produces 12,000 tons of toluol and xylol; 6,000 tons of ethylene oxide and 4800 tons of ethylene glycol. Several other polyethylene plants are being built in Japan.

• In order to stimulate her chemical industries, Russia is building several chemical research centers. The first of these will be built in Jaroslav in the former province of Galicia and will specialize in the field of synthetic rubbers. The Research Department will develop new processes for the production of monomers.

A new research center for petrochemistry will be opened in Ufa, the capital of Baschkiria. In Nowosibirsk and Kemerowo, industrial centers in Siberia, branches of the plastic and adhesive research centers of Mocow and Leningrad will be constructed.

The capital of Armenia, Jerewan, will be the site of a branch of the Leningrad Institute for Synthetic Rubber Research. A number of existing research laboratories in Kiew and Krassnojarsk will also be enlarged in order to intensify the research and development activities on synthetic fibers.

• German housewives complain about the new wall or plaster boards and other materials which crack when they try to drive a nail or hook into the wall. Following the experience of Americans, they now use adhesives to glue the hooks to the walls. Although similar devices consisting of plastic hooks with the added adhesives have been on the domestic market for several years, the sale of these items has been lagging.

• East Germany has published statistics covering production figures of selected products. It is, of course, not easy to check whether or not the figures are correct. However, we have juxtaposed its production figures with those of West Germany, which have been compiled by the German Federal Office for Statistics in Wiesbaden. West German figures are not absolutely correct because they do not include the production figures of West Berlin. East Germany, having free access to East Berlin, does include production figures of the capital.

East German production of animal glues were 3213 metric tons in 1952; 4182 metric tons, 1953; 4830 metric tons, 1954; 4970 metric tons, 1955; and 4616 metric tons in 1956. West Germany produced 21,632 metric tons of animal glues in 1952; 23,766 metric tons in 1953; 27,137 metric tons, 1954; 28,303 metric tons, 1955; and 28,517 metric tons in 1956.

Comparing the two sets of figures, a decrease in the Eastern Zone in 1956, contrasts with an increase in the Western Zone during that year. It can be assumed that production in West Germany continued to rise during 1957.

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Modified Epoxy Resin Adhesives for

Glass-to-Metal Bonding

By Marco Petronio, Henry Gisser and Arthur W. Forbriger, Jr.

Frankford Arsenal, Philadelphia 37, Penna.

► **The following study was undertaken to investigate modifications of epoxy resins for glass-to-metal bonding at room temperature with contact pressure. It was desired to provide flexibility at −70°F. and to retain both high bond strength at 160°F. and bond stability on aging.**

The modifiers consisted of polysulfide liquid polymers, polyamide resins and resins derived from mono and di (hydroxyphenyl) pentadecanes. Three amine catalysts were studied and the resulting systems were evaluated for resistance to thermal shock, bond strength and aging stability.

Two adhesive formulations are given which were found to possess the desired flexibility, bond strength and aging stability. Curing can be accomplished at room temperature or at 160°F. and their working life is about 60 and 90 minutes. A mechanism is given for the curing of epoxy-polysulfide copolymers catalyzed with dimethylaminomethylphenols.

Metal to glass adhesives are used extensively in Ordnance instruments to bond optical elements to their supports. The adhesive is generally applied in an appreciably thick layer to prevent a relatively large difference in thermal expansion between the metal and glass without rupture of the bond. The currently used adhesive is a neoprene modified phenolic, the use of which involves a very cumbersome and time consuming technique which is required to attain the desired thickness without deleterious solvent entrapment.

The technique also involves cumbersome process control with respect to heat treatment of assemblies to achieve bonded members free from undesirable strain. Even after proper precautions are taken, large flat components, such as mirrors, are often permanently strained during the bonding procedure. Improvements are therefore needed in both the application techniques and in the final properties, particularly flexibility of the cement.

The epoxy resins are attractive as base materials for glass to metal bonding because they exhibit excellent adhesion to both substrates and may be conveniently cured at room temperature by appropriate catalysts. However, the flexibility of epoxy resins is considerably lower than the level required for glass to metal adhesives. This work was therefore undertaken to study the modification of epoxy resins to yield a room temperature curing product having desired flexibility in addition to other desired properties.

Lap shear tensile specimens consisted of two aluminum adherends sandwiching a plate of glass, having a bond area of one-half square inch. A piece of 15 mil thick fiber-glass mat was placed in each adhesive layer between the glass and aluminum. This allowed for an adhesive film of uniform thickness. The adherends 1 x 4 x 0.064 inch were made from aluminum alloy 2024. The glass plates 1 x ⅝ x 0.05 inch were cut from laboratory microslides.

One side of the glass plate was bonded completely (⅝ square inch) to one of the aluminum adherends. The other side of the glass was bonded to the other aluminum adherend over an area of ½ square inch. The glass mat was type SM, from Modigliani Glass Fibers Inc. and consisted of single, woven fibers oriented in a generally diagonal pattern at an approximately 90° angle to each other. The mat was very porous allowing easy penetration of the adhesive.

The aluminum adherends were cleaned successively in toluene, sodium metasilicate solution, and sodium dichromate-sulfuric acid solution followed by a water rinse. The glass plate and fiber glass were used as received from the manufacturer. In the case of adhesives catalyzed with primary or secondary amines, *e.g.* diethylenetriamine, the resinous components were first mixed together in the proper proportions and then the amine was added just prior to use. In the case of dimethylaminomethylphenols used as catalysts for epoxy-polysulfide mixtures, the dimethylaminomethylphenol was added to the polysulfide and the epoxy resin was then added just prior to use.

Where maleic anhydride was used in combination with dimethylaminomethylphenol, the maleic anhydride was added to the polysulfide and the mixture was heated to about 158° F. until the maleic anhydride dissolved. The mixture was allowed to cool and the dimethylaminomethylphenol was added. The epoxy resin was added just prior to mixing.

When inert fillers were employed they were added to the epoxy resin component in the proper proportion. In all cases, mixing was accomplished by stirring, either by hand or with a power stirrer.

A thin film of adhesive was applied to both aluminum adherends over an area of approximately ¾ square inch. A piece of glass fiber mat, 15 mils thick and 1 x ¾ inch was placed on each adhesive coated aluminum adherend. Next the glass was coated on one side with adhesive and placed on one aluminum adherend. The other side of the glass was then coated and the second aluminum adherend was positioned with sufficient pressure to squeeze out the excess adhesive. This assembly was held in place by a piece of ½ inch wide cellophane tape until the adhesive was cured.

To summarize, the lap shear specimen consisted of five components arranged in the following order: (1) aluminum adherend, (2) fiber glass mat impregnated with adhesive, (3) glass microslide, (4) fiber glass mat impregnated with adhesive, and (5) aluminum adherend. The fiber glass mat acts as a reinforcement and maintains a desired and uniform adhesive thickness.

Accomplishing Curing

Curing was accomplished at either 77° F. or at 160° F. No pressure other than contact pressure was used. Aging was accomplished in the same manner. In the case of conditioning at 160° F. and 100 per cent relative humidity, the specimens were placed in a sealed container over water and the container placed in an oven at 160° F.

Prior to testing, the specimens were conditioned for one hour at the temperature at which they were to be tested. Specimens which were not tested at room temperature were conditioned and tested in a controlled temperature box that was mounted around the jaws of the testing machine.

All specimens were pulled at a rate of 0.05 inch per minute jaw separation. The breaking load was noted and recorded as was the nature of the bond failure.

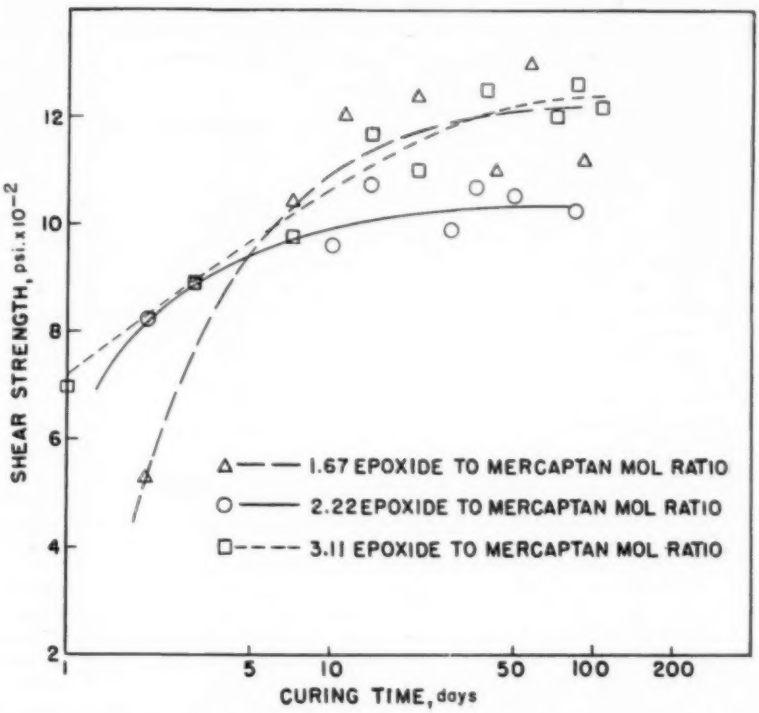


FIG. 1—Effect of curing at 77°F. on shear strength at 77°F. of epoxy-polysulfide adhesives at various epoxide to mercaptan mol ratios.

The prism specimen consisted of a right angle prism, 2 x 2 x 2 inches bonded to a plate 3 x 3 x 0.25 inches of aluminum alloy 7075. The prisms were reported to be made from strain free, boro silicate crown glass with a ground finish on the surfaces to be bonded. A triangular piece of 15 mil fiber glass mat was placed between the prism and the aluminum plate.

The cleaning methods were the same as for the lap shear specimens. Both the prism and aluminum plate were coated with a thin film of adhesive. The fiber glass mat was placed on the aluminum plate and the adhesive allowed to soak through. The prism was placed on the mat with enough pressure to squeeze out the excess adhesive. Curing was accomplished in the same manner as for lap shear specimens.

For the thermal shock test, the prism assemblies contained in a box fitted with a plexiglas lid to permit observation were placed in a low temperature cabinet refrigerated by circulating air over dry ice. The purpose of the box was to protect the prisms from the blast of cold air. The prisms were placed in a cold cabinet with the latter at room temperature, and lowered to —70° F. in approximately 90 minutes and maintained at that temperature for three hours. The cabinet was allowed to warm to room temperature overnight and the same cycle repeated. Two cycles were run and the assemblies observed after each cycle.

The working life of the adhesive formulations was determined by measuring the time required for the mixed adhesive to gel. A meter was used to measure gelation time at 77° F. A millimeter scale was attached between the contact points and the change in gap distance with time was determined. The data for Figure 1 was obtained in this manner.

In evaluating reactive plasticizers, the modifiers selected for study were of the type that react chemically with the epoxy resins, forming copolymers. In addition to providing low temperature flexibility, modifiers should not lead to reduction in adhesive and cohesive strength over the temperature range —65° F. to 160° F.

Three types of compounds were chosen for study as modifiers for epoxy resins. They were polysulfide liquid polymers, polyamide resins and resins derived from mono and di(hydroxyphenyl) pentadecanes. A discussion of these compounds and

the manner in which they co-react with epoxy resins is presented below. The epoxy resins studied are:

Resin	*Avg. Mol. Wt.*	*Epoxide Equivalent*
Epoxy A	300	150
Epoxy B	400	200
Epoxy C	500	250
Epoxy D	400	500
Epoxy E	550	425

Epoxy resin A is reported as being a condensation product of glycerol and epichlorohydrin. The terminal groups are probably glycidal ether groups. Epoxy resins B and C are representative of the bulk of commercially available epoxy resins in that they are the condensation product of bisphenol A and epichlorohydrin. Epoxy resins D and E differ from other epoxy resins in that the phenols from which they are derived are mono and di (hydroxyphenyl) pentadecane, respectively. In the latter compound the aromatic groups are separated by a chain of eight carbon atoms and this chain would be expected to contribute to increased flexibility of the resin. Like the other epoxy resins these resins are crosslinked at room temperature by amines.

The epoxy resins can be crosslinked through both the epoxide and hydroxyl groups. In the case of room temperature cures with amine catalysts, cross-linking through the epoxide ring is predominant.

Polysulfide Liquid Polymers. Polysulfide liquid polymers are mercaptan terminated polymers prepared from bis(2-chloroethyl)formal and cross-linked with trichloropropane.

The polymers studied in this project are listed below. Mercaptan equivalent refers to grams per gram mol SH.

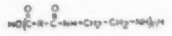
Polymer	*Avg. Mol. Wt.*	*Mercaptan Equivalent*
Polysulfide F	4000	1600
Polysulfide G	4000	2000*
Polysulfide H	1000	500
Polysulfide I	1000	500**

* lower cross-linked variation of Polysulfide F

** lower cross-linked variation of Polysulfide H

These polymers copolymerize with epoxy resins through an addition reaction between the mercaptan and epoxide groups. This reaction is catalyzed at room temperature by acids and bases. Amines are the most common catalyst.

Polyamide Resins. These resins are condensation products of dimerized and trimerized unsaturated fatty acids, c.g., linoleic acid, with aliphatic amines such as ethylene diamine. Their general structure is



where n varies from 5 to 15.

While this work was in progress only one polyamide resin J was available in liquid form at room temperature. This polyamide resin copolymerizes rapidly with epoxy resins at room temperature to form a thermosetting resin. No catalyst is required for this reaction and increasing the amount of polyamide resin results in more rapid reaction rates.

Amine Catalysts. In the initial study of polysulfide polymers and epoxy resins the catalysts used were ethylenediamine (EDA), and diethylenetriamine (DTA).

Modification of epoxy resins with polysulfide polymers and epoxy resins was very straight forward. The percentage of modifier was increased until test bonds successfully passed two cycles of thermal shock. Since resins D and E are epoxy resins, they were evaluated by themselves as well as in combination with the other epoxy resins.

The adhesives that withstood thermal shock at −70° F. were then compared for shear strengths at 77° F. The results of these tests are listed in Table I. They indicate that greater bond strengths can be obtained with polysulfide modifiers than with resins D and E. Modification with polyamide resins resulted in several difficulties which eliminated them from consideration as modifiers. The high percentage of polyamide required to produce the low temperature flexibility resulted in increased viscosity and gel-time. The polyamide-epoxy combinations required post curing at elevated temperatures to develop these full strengths. Curing at elevated temperatures did not produce a shear strength equal to that obtained with the epoxy-polysulfide polymers.

In the course of this project several commercial epoxy-polysulfide adhesives were studied for bonding glass to metal. None of these adhesives were found to have sufficient low temperature flexibility to withstand the thermal shock at −70° F. However, one adhesive cured with diethylenetriamine gave very interesting results when modified with additional polysulfide. Table II shows that when sufficient polysulfide was added, the resulting adhesive passed the thermal shock test at −70° F.

Further testing revealed that curing at 160° F. for 16 hours produced much lower shear strengths than curing at 77° F. for one week. At first this was believed to be due to evaporation of the catalyst before the adhesive was fully cured. But this could not be so because a similar decrease in shear strength occurred when the adhesive was cured at 77° F. for six weeks.

In order to develop an adhesive that retained the high shear strength and good low temperature flexibility, but eliminated the poor aging characteristics of the modified commercial adhesive, it became necessary to duplicate these tests with laboratory adhesive formulations.

For initial testing, 40 parts of epoxy resin B and 60 parts of polysulfied polymer H were catalyzed with dimethylaminomethylphenols. The results are given in Table III and it is at once apparent that an additional cure at elevated temperature considerably decreased the shear strength.

Difference Between Systems

The difference between the behavior of systems cured with diethylenetriamine and the dimethylaminomethylphenols was attributed by Jorczak and Belisle (*1*) to the fact that the latter contains only tertiary amine groups, and forms coordinate covalent bonds through a pair of unshared electrons of the nitrogen. The drop in shear strength is presumed by them to be due to the instability of the nitrogen bonds at elevated temperatures. Diethylenetriamine, containing primary and secondary amine groups formed stable covalent bonds.

If this is the case, then a drop in strength should occur when 100 per cent epoxy resin, catalyzed with 2, 4, 6-tris(dimethylaminomethyl) phenol, is exposed to aging at elevated temperatures.

Data were obtained on the shear strength of diethylenetriamine and 2, 4, 6-tris(dimethylaminomethyl) phenol cured epoxy resins at room temperature and at elevated temperatures. From Figure 2 it will be noted that the 2,4,6-tris(dimethylaminomethyl)phenol does not cure the epoxy resin as rapidly at room temperature as does the diethylenetriamine, and also that the shear strength of the bond system cured with 2, 4, 6-tris(dimethylaminomethyl) phenol does not decrease on exposure to high temperature. Quite the contrary, both gave a substantial

increase in shear strength when cured at 250° F. On continued exposure to 250° F. there was no appreciable drop in shear strength.

This indicates that the drop in shear strength occurs with aging when polysulfide polymer is used in combination with epoxy resin and cured with 2,4,6-tris(dimethylaminomethyl)phenol. To verify this, tests were conducted using various weight ratios of epoxy resin B and polysulfide polymer H.

The results, reported in Table IV, indicate that the drop in shear strength on heating becomes more evident as the percentage of polysulfide polymer H increases. A sharp change in strength occurs between the 60/40 and 40/60 epoxy B/polysulfide H weight ratio. From the standpoint of heat stability the 60/40 ratio is excellent. Unfortunately, a 40/60 ratio is required to produce the required low temperature flexibility.

The optimum combination would be the heat stability of the 60/40 ratio and the low temperature flexibility of the 40/60 ratio. The low temperature flexibility, which is a physical property of the adhesive is primarily dependent on the weight ratio of the two polymers, provided of course that the method of cross-linking is not a variable. On the other hand, any change in the structure of the copolymer on aging is chemical in nature, resulting from changes in the chemical bonds of the molecule.

Changing Weight Ratio

Although the data indicates that changing the weight ratio changes the heat stability, more important is the fact that changing the weight ratio changes the mol ratio of epoxide to mercaptan groups. This change affects the chemical reactivity of the system and consequently affects the stability of the copolymer.

The problem then resolves itself into (1) maintaining the 40/60 epoxy/polysulfide weight ratio in order to obtain the required low temperature flexibility and (2) maintaining the mol ratio of epoxide to mercaptan of the 60/40 weight ratio in order to obtain good heat stability. It is evident that this can be accomplished by using a lower molecular weight epoxy resin and a higher molecular weight polysulfide liquid polymer.

Table V lists the results of replacing epoxy resin B with epoxy resin A and replacing polysulfide polymer H with polysulfide polymer F. Changing only the epoxy resin did not eliminate the drop in strength

Table I—Evaluation of Reactive Modifiers

A—Polysulfide Modifiers

Epoxy Resin B (pt. by wt.)	Polysulfide H (pt. by wt.)	Polysulfide I (pt. by wt.)	Diethylene triamine (pt. by wt.)	Results of Thermal Shock at −70° F.	Lap Shear Strength at 77° F., psi: Cured two weeks at 77° F.	Lap Shear Strength at 77° F., psi: Cured 16 hours at 160° F.
50	50	—	5.0	Prism cracked	650	—
45	55	—	4.5	Prism cracked	—	—
40	60	—	4.0	Passed	650	670
50	—	50	5.0	Prism cracked	—	—
45	—	55	4.5	Prism cracked	—	—
40	—	60	4.0	Passed	600	630

B—Epoxy Resin Modifiers

Epoxy Resin (pt. by wt.) B	C	D	E	Diethylene-triamine (pt. by wt.)			
50	—	50	—	5	Prism cracked	—	—
40	—	60	—	5	Prism cracked	—	—
35	—	65	—	5	Passed	470	500
—	45	55	—	5	Prism cracked	—	—
—	40	60	—	5	Prism cracked	—	—
—	35	65	—	5	Bond failure	—	—
—	4	40	60	5	Prism cracked	—	—
—	—	50	50	5	Prism cracked	—	—
—	—	65	35	5	Passed	320	320

Table II—Modification of Epoxy-Polysulfide Adhesive

Commercial Adhesive (pt. by wt.)	Polysulfide I	Results of Thermal Shock at −70° F.	Lap Shear Strength at 77° F., psi: Cured at 77° F. 1 week	Cured at 77° F. 6 weeks	Cured at 160° F. 16 hours
100	30	Prism cracked	—	—	—
100	35	Prism cracked	—	—	—
100	40	Prism cracked	—	—	—
100	50	Passed	800	200	200

Table III—Effect of Functionality and Concentration of Catalyst

Epoxy Resin B	Polysulfide H	2-dimethylaminomethylphenol	2,4,6-tris (dimethylaminomethyl) phenol	Lap Shear Strength at 77° F., psi: Cured 7 days at 77°F.	Lap Shear Strength at 77° F., psi: Cured 7 days at 77° F. + 1 hr. at 250° F.
40	60	4	—	760	180
40	60	—	4	1000	200
40	60	—	2	700	150
40	60	2	2	900	210

entirely but there was a marked improvement. The drop in strength proved to be only temporary and was regained on prolonged heating.

When polysulfide polymer F was substituted for polysulfide polymer H the resulting mixture would not cure at room temperatures due to the low reactivity of the high molecular weight polysulfide F. Further testing indicated that a mixture of 25 parts polysulfide F and 35 parts polysulfide H when copolymerized with 40 parts epoxy resin A resulted in satisfactory room temperature cure and eliminated the drop in shear strength on heating.

It will be noted that in Table V the amount of 2,4,6-tris(dimethylaminomethyl)phenol is increased as compared to formulations in Table III and IV. Also a small amount of maleic anhydride is added. During initial formulating with 2,4,6-tris(dimethylaminomethyl)phenol it was noted that the working life was limited to about 15 to 20 minutes. This was too short to make the adhesive practical for manufacturing operations.

The use of maleic anhydride enabled extension of the working life and it did not interfere with room temperature curing. Figure 3 shows the effect of maleic anhydride on working life and shear strength. Because 2,4,6-tris(dimethylaminomethyl)phenol and maleic an-

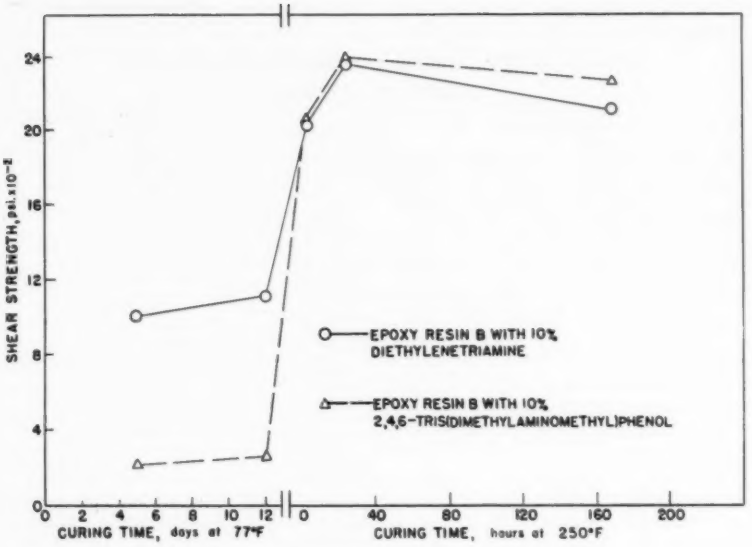


FIG. 2—Effect of curing on shear strength.

hydride are both catalysts for epoxy-polysulfide copolymers, the total amount of the two catalysts per 100 parts of resin was maintained constant at 10 and 12 and the ratio of the two was varied.

It can be seen that this produced an almost linear relationship between the ratio of 2,4,6-tris(dimethylaminomethyl)phenol to maleic anhydride and the working life. Also the working life is quite independent of the total amount of catalyst. On the other hand the maximum shear strength obtained decreased considerably when the total amount of catalyst was decreased from 12 to 10.

To determine the effect of changing the mol ratio of epoxide to mercaptan groups, three of the adhesive formulations for which data are given in Table V (the first, second, and fifth listed) were evaluated further under various curing and aging conditions. In these formulations the weight ratio of epoxy resin to polysulfide was held constant, as was the catalyst concentration.

Epoxy resins and polysulfide polymers of different molecular weights were used to give varied epoxide to mercaptan group mol ratios. The shear strengths of the three adhesives were evaluated under the following sets of conditions: curing at 77° F., curing 2 weeks at 77° F. and aging at 160° F., curing at 160° F., and curing 3 hours at 160° F. and aging at 77° F.

It is apparent from Figure 1 that there is very little difference among the three adhesives when cured and aged at room temperature. When aged at 160° F., however, there is a striking dependency of shear strength on composition, as indicated in Figure 4. The adhesive having the lowest epoxide to mercaptan ratio suffers an apparently permanent loss in shear strength, the adhesive with the intermediate epoxide to mercaptan ratio suffers a temporary loss in shear strength, which then increases and exceeds its initial value. The adhesive with the highest epoxide to mercaptan mol ratio steadily increases in shear strength during the elevated temperature aging.

Figures 4 and 5 show very little difference in the three adhesives when they are cured initially at 160° F. and aged at both 77° F. and 160° F. It is unfortunate that epoxy resin A was the only available epoxy resin with an appreciably lower molecular weight than epoxy B. Epoxy A is not a lower homolog of epoxy B. The structure of epoxy A is not available at this writing. It may be that the different structure as well as the lower molecular weight of epoxy A affects the aging stability. However, it should be noted that in the two formulations containing epoxy A, an appreciable change is effected through the use of polysulfide F, which is a higher homolog of polysulfide H.

Interesting deductions can be made from a study of Figure 6. The initially higher strength of the adhesive of lowest epoxide to mercaptan ratio (the only formula containing epoxy B) can most probably be attributed to the structure difference in epoxy A and B. The fact that the adhesive of intermediate ratio undergoes a temporary drop in shear strength indicates that there are probably two different structures of the cured adhesives, and that the structure obtained by curing at 77°F. is not a stable one.

According to Figure 4, initial curing at 160°F. produces a stable bond in all three adhesives. Evidently heat curing when the adhesive is a liquid and the molecules are more mobile, accelerates the cure to the stable structure very rapidly.

The composition of GMA-10 was as follows:

Part A

40 parts Epoxy resin A
38 parts Aluminum silicate filler

Part B

25 parts Polysulfide polymer F
35 parts Polysulfide polymer H
2 parts Maleic anhydride
16 parts 2-Dimethylaminomethylphenol

The composition of GMA-30 is given below:

Part A

40 parts Epoxy resin A
32 parts Aluminum silicate filler

Part B

25 parts Polysulfide polymer F
35 parts Polysulfide polymer H
2 parts Maleic anhydride
10 parts 2,4,6-Tris(dimethylaminomethyl)phenol

The formula coded GMA-10 represents glass to metal adhesive with 2-dimethylaminomethylphenol, and GMA-30 represents the same except with 2,4,6-tris(dimethylaminomethyl)phenol.

The test adhesives were made in two parts for convenience in handling. The adhesives were prepared by mixing equal weights of the two parts. The working life of the mixed adhesives is approximately 90 minutes for GMA-10 and 60 minutes for GMA-30.

Figure 7 shows the rate of viscosity increase as measured by decrease in gap width during a working life determination on adhesive formulations GMA-10 and GMA-30. These are compared to the rate of viscosity increase of a formulation identical to GMA-30 but with no maleic anhydride. With GMA-10 and GMA-30 the initial increase in viscosity is gradual and small, allowing a longer working life. GMA-10 due to the lower functionality of the 2-dimethylaminomethylphenol has a slightly longer pot life.

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The results of the thermal shock test on these adhesives are reported in Table VI. GMA-10 passed this test with no failures after curing at both 77°F. and at 160°F. GMA-30 passed after curing at 160°F. but failed to pass after curing at 77°F. until the specimen had cured for approximately six weeks at 77°F. These tests again indicate that there are two different structures of the cured materials. The fact that the properties of GMA-30 improve as the adhesive continues to cure at 77°F. indicates that the structure is changing slowly, even at 77°F.

The results of lap-shear strength tests at various temperatures are reported in Table VII. GMA-30 is superior to GMA-10 in shear strength at the elevated temperatures. GMA-30 also shows marked strength at the low temperature after curing at 160° F.

To determine the effect of extreme moisture conditions on the adhesive bonds, lap-shear specimens were exposed at 160°F. and 100 per cent relative humidity. After 72 hours the bonds were found to be destroyed.

Narracott(*2*) studied the curing of epoxy resins with tertiary amines through the reaction between phenyl glycidyl ether and triethylamine, and found that regardless of the extent of polymerization, the same amount of nitrogen was found to be present. He therefore proposed the following reactions for the polymerization of phenyl glycidyl ether with triethylamine.

Table IV—Effect of Epoxy-Polysulfide Weight Ratio

Epoxy Resin B (pt. by wt.)	Polysulfide H (pt. by wt.)	2,4,6-tris-(dimethylaminomethyl) phenol	Lap Shear Strength at 77° F., psi		Results of Thermal Shock at −70° F.
			Cured 7 days 77° F.	Cured 7 days 77° F. + 1 hr. 250° F.	
100	0	10	200	2750	—
80	20	8	920	3470	—
60	40	6	2050	2200	Failed
40	60	4	1000	200	Passed

Table V—Effect of Epoxy to Polysulfide Molecular Weight Ratio
When Cured with Ten Parts 2,4,6-Tris (dimethylaminomethyl) phenol and Two Parts Maleic Anhydride

Epoxy Resin (pt. by wt.)		Polysulfide Polymer (pt. by wt.)				Lap Shear Strength at 77° F., psi		
A MW-300	B MW-400	F MW-4000	H MW-1000	G MW-4000	I MW-1000	Cured 7 days at 77° F.	Cured 7 days at 77° F. + 1 hr. at 250° F.	Cured 7 days + 24 hrs. 250° F.
—	40	—	60	—	—	1050	400	130
40	—	—	60	—	—	1020	530	1280
40	—	60	—	—	—	Gummy		
40	—	30	30	—	—	800	900	1200
40	—	25	35	—	—	1000	1350	1600
—	40	25	35	—	—	1320	730	690
40	—	—	—	25	35	960	1379	1420

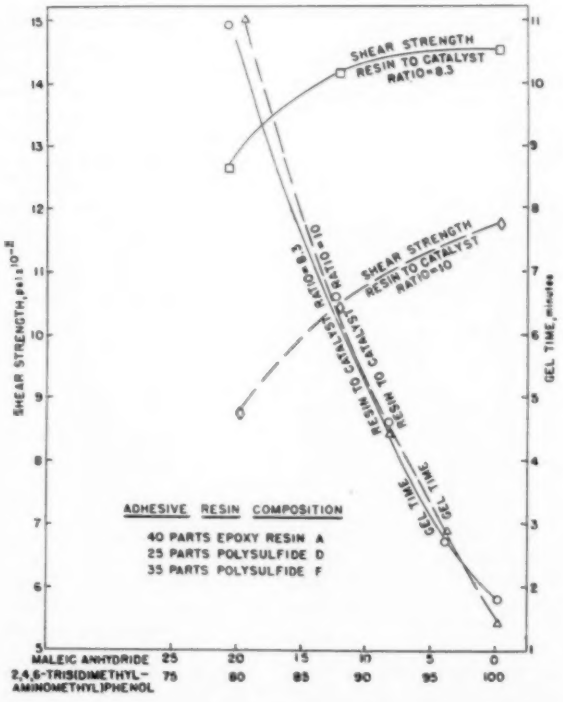
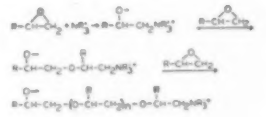
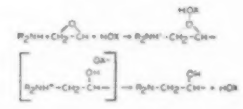

SHEAR STRENGTH RESIN TO CATALYST RATIO=8.3
SHEAR STRENGTH RESIN TO CATALYST RATIO=10
GEL TIME RESIN TO CATALYST RATIO=8.3
GEL TIME RESIN TO CATALYST RATIO=10
ADHESIVE RESIN COMPOSITION
40 PARTS EPOXY RESIN A
25 PARTS POLYSULFIDE D
35 PARTS POLYSULFIDE F
SHEAR STRENGTH, psi x 10⁻²
GEL TIME, minutes
MALEIC ANHYDRIDE 25 20 15 10 5 0
2,4,6-TRIS(DIMETHYL-AMINOMETHYL)PHENOL 75 80 85 90 95 100

FIG. 3—Effect of maleic anhydride on 2,4,6-tris (dimethylaminomethyl) phenol concentration on gel-time (for a 6mm gap) and shear strength (cured six week at 77°F.) on epoxy-polysulfide adhesive.



Shechter (*3*), found that the amine-glycidyl ether reaction was markedly accelerated by hydroxyl groups which were either generated during their reaction or provided by the addition of a suitable solvent. Phenol, for example, was a very active catalyst. This was attributed to phenol aiding in opening the epoxide ring by hydrogen bonding in the transition state, *i.e.*, a concerted termolecular reaction as indicated below. Here X = aromatic group.



The dimethylaminomethylphenols have both tertiary amine and phenol groups on the same molecule. The presence of the phenol group must account for the rapid cure rates obtained with GMA-10 and GMA-30, since a tertiary aromatic amine alone would not be expected to provide a rapid cure. In fact α-methylbenzyldimethylamine produced no cure at

Table VI—Results of Thermal Shock Test of Prism Assemblies with GMA-10 and GMA-30

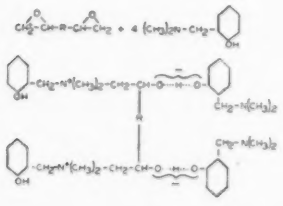
GMA-10			GMA-30		
	Test Results			Test Results	
Cure Conditions	1st Cycle	2nd Cycle	Cure Conditions	1st Cycle	2nd Cycle
7 days at 77° F.	Passed	Passed	10 days at 77° F.	Failed	
7 days at 77° F.	Passed	Passed	10 days at 77° F.	Failed	
" " " "	"	"	" " " "	"	
" " " "	"	"	" " " "	"	
10 days at 77° F.	"	"	4 weeks at 77° F.	Passed	Failed
" " " "	"	"	" " " "	"	Passed
" " " "	"	"	5 weeks at 77° F.	"	Failed
" " " "	"	"	" " " "	"	"
2 weeks at 77° F.	"	"	6 weeks at 77° F.	"	Passed
" " " "	"	"	" " " "	"	"
" " " "	"	"	7 weeks at 77° F.	"	"
" " " "	"	"	7 weeks at 77° F.	"	"
" " " "	"	"	4 hours at 160° F.	"	"
" " " "	"	"	" " " "	"	"
3 weeks at 77° F.	"	"	" " " "	"	"
" " " "	"	"	" " " "	"	"
4 weeks at 77° F.	"	"	" " " "	"	"
" " " "	"	"	" " " "	"	"
5 weeks at 77° F.	"	"	" " " "	"	"
" " " "	"	"	" " " "	"	"
4 hours at 160° F.	"	"			
" " " "	"	"			
" " " "	"	"			
" " " "	"	"			

Table VII—Effect of Temperature of Shear Strength of GMA-10 and GMA-30 After Curing at 77°F. and 160°F.

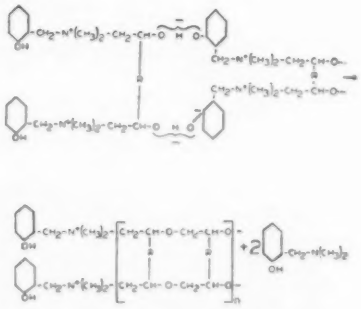
		Shear Strength in psi When Tested at:			
Adhesive	Cure	−65° F.	77° F.	120° F.	160° F.
GMA-10	4 weeks at 77° F.	1130	1075	350	140
GMA-10	4 hours 160° F.	1140	1030	355	190
GMA-30	4 weeks 77° F.	990	1200	520	240
GMA-30	4 hours 160° F.	1530	1200	820	330

77°F. when used with the resin components of GMA-30.

Applying the conclusions of Narracott and Shechter to the reaction of one mol of epoxide resin (2 epoxy groups) with four mols of 2-dimethylaminomethylphenol leads to the following mechanisms:



Through this mechanism it is possible to continue to form a very highly cross-linked, three dimensional structure. This structure would be very brittle and low in strength due to the low energy of the hydrogen bond. This mechanism would account for dimethylaminomethylphenols rapidly curing epoxy resins to a hard but weak polymer at room temperature. On heating the structure changes, and polymerization continues according to Narracott by formation of the ether linkage between epoxy molecules as illustrated below:

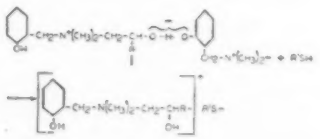


In the former case the 2-dimethylaminomethylphenol acts as a curing agent and becomes an integral part of the polymer. In the latter the 2-dimethylaminomethylphenol provides a catalytic effect to link the epoxy resin molecules together.

The curing of epoxy resins with dimethylaminomethylphenols would probably follow both Narracott's and Shechter's mechanisms. It would be expected that at room temperature, at least for a short period of time, a cross-linked structure would be obtained in which the cross-links through ether linkages. bonds from the epoxy oxygen to the phenolic hydrogen.

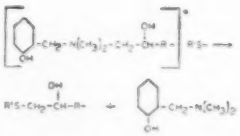
On heating, and possibly on storage for long periods of time at room temperature, the material would probably react further releasing some of the amine and forming cross-links through ether linkages. But it is to be expected that a short room temperature cure would yield bond strengths which would be changed considerably on either further storing at room temperature or on further high temperature curing.

The introduction of a mercaptan terminated polysulfide polymer provides active hydrogen to open the epoxy ring. And a polymer of the following structure would be expected:



The epoxy resin and polysulfide polymer are here linked through an ionic bond involving the tertiary amine group. This is believed to be the structure obtained during a room temperature cure of the epoxy polysulfide copolymers with the dimethylaminomethylphenols. It should be noted here that the 2,4,6-tris(dimethylaminomethyl)phenol would produce a more rigid polymer than the 2-dimethylaminomethylphenol.

When an epoxy-polysulfide copolymer is cured at 160°F. it is believed that the structure rearranges according to the following reaction:



This reaction is supported by the data which show that copolymers catalyzed with 2,4,6-tris(dimethylaminomethyl)phenol have better low temperature flexibility when cured at 160°F. than when cured at 77°F. According to the reaction postulated for room temperature curing, where the amine is chemically tied into the structure, the following structure would be formed when 2,4,6-tris(di-

FIG. 6—Effect of curing at 160°F. on shear strength at 77°F. of epoxy-polysulfide adhesives (after initial two week cure at 77°F.) at various epoxide to mercaptan mol ratios.

FIG. 7—Change in viscosity with time as measured on gel-time meter at 77°F.

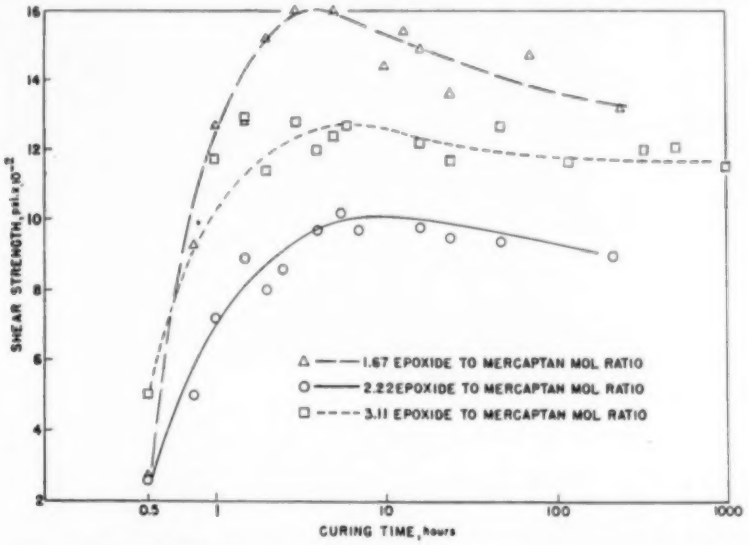

SHEAR STRENGTH, psi x 10⁻²
CURING TIME, hours
1.67 EPOXIDE TO MERCAPTAN MOL RATIO
2.22 EPOXIDE TO MERCAPTAN MOL RATIO
3.11 EPOXIDE TO MERCAPTAN MOL RATIO

FIG. 4—Effect of curing at 160°F. on shear strength at 77°F. of epoxy-polysulfied adhesives at various epoxide to mercaptan mol ratios.

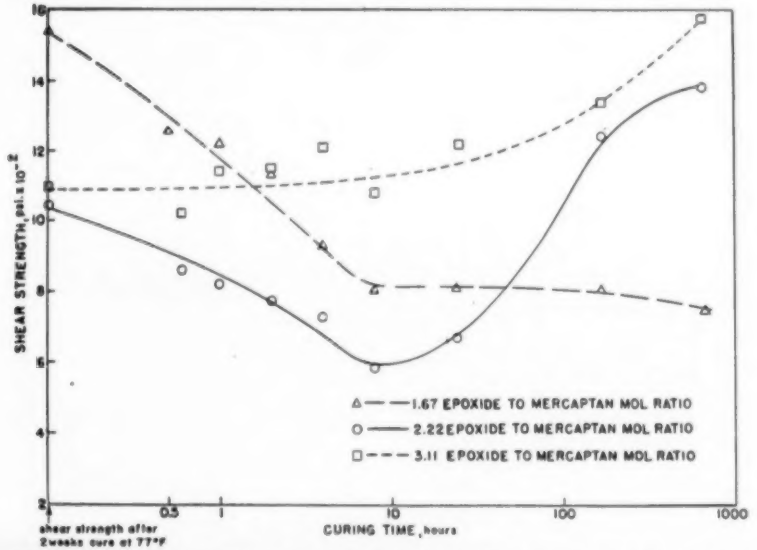

SHEAR STRENGTH, psi x 10⁻²
shear strength after 2 weeks cure at 77°F
CURING TIME, hours
1.67 EPOXIDE TO MERCAPTAN MOL RATIO
2.22 EPOXIDE TO MERCAPTAN MOL RATIO
3.11 EPOXIDE TO MERCAPTAN MOL RATIO

FIG. 6—Effect of curing at 160°F. on shear strength at 77°F. of epoxy-polysulfide adhesives (after initial two week cure at 77°F.) at various epoxide to mercaptan mol ratios.

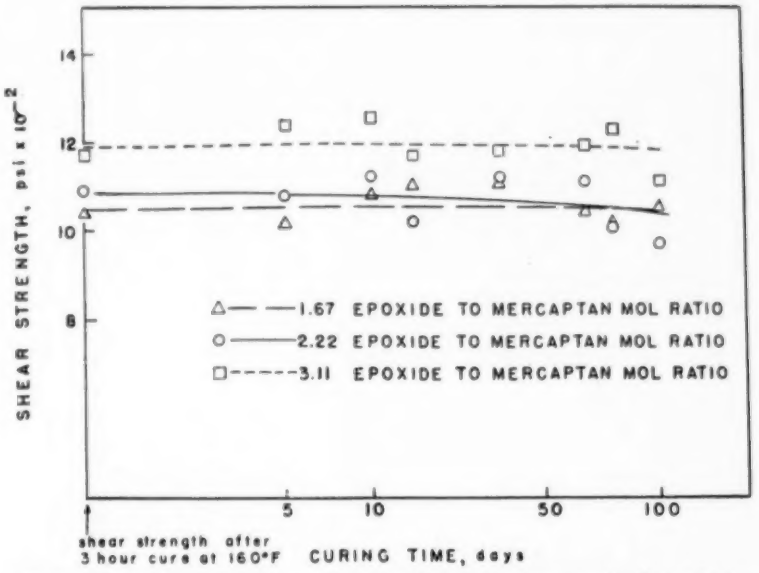

SHEAR STRENGTH, psi x 10⁻²
shear strength after 3 hour cure at 160°F
CURING TIME, days
1.67 EPOXIDE TO MERCAPTAN MOL RATIO
2.22 EPOXIDE TO MERCAPTAN MOL RATIO
3.11 EPOXIDE TO MERCAPTAN MOL RATIO

FIG. 5—Effect of curing at 77°F. on shear strength at 77°F. of epoxy-polysulfied adhesives (after initial three hour cure at 160°F.) at various epoxide to mercaptan mol ratios.

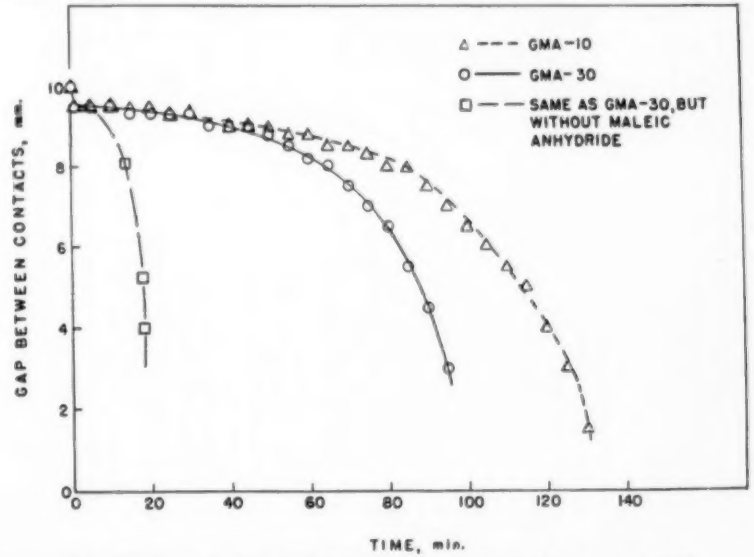
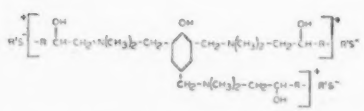


FIG. 7—Change in viscosity with time as measured on gel-time meter at 77°F.

methylaminomethyl)phenol is the catalyst.



It is evident that this structure is highly cross-linked and three dimensional. However, if with a 160°F. cure the structure rearranges as postulated above and the amine is released from the structure, a more linear and more flexible polymer is formed. The structure must be essentially linear as both the epoxy resin and polysulfide liquid polymer are primarily bifunctional.

When 2-dimethylaminomethylphenol is the catalyst, it can be seen that a linear structure is formed whether the amine is tied into the structure or not. This is supported by the data which indicates that 2-dimethylaminomethylphenol produced good low temperature flexibility regardless of the curing temperatures used.

Polysulfide modified epoxy resin adhesive formulations have improved low temperature flexibility. The minimum weight ratio of polysulfide to epoxy resin required is approximately 60:40. Also, the higher the mol ratio of epoxy groups to mercaptan groups the greater the shear strength and the better the aging properties.

Dimethylaminomethylphenols containing both tertiary amines and phenolic groups first act as curing agents and become part of the polymer and on heating they provide a catalytic effect and result in a rearrangement of the structure to form a linear and more flexible polymer.

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About the Authors . . .

Petronio

Gisser

MARCO PETRONIO, chief of the Industrial Chemistry Unit, has been engaged in adhesives, sealants and lubricants research since 1940. He graduated from City College of New York in 1937 with a degree in chemical engineering.

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Bonding Fresh to Cured Concrete

One of the biggest and oldest problems in the construction industry —joining fresh wet concrete to cured concrete—has been overcome with the perfection of a new epoxy-nylon "alloy." The compound forms a permanent joint and moisture barrier by literally welding the entire contact area without any mechanical interlocking.

Tension, compression, shear and impact tests made on bonds effected with Uniweld show them to be many times stronger and tougher than even fully hardened concrete. The new structural welding agent was developed by Permagile Corp. of America after years of preliminary research.

Thermo-setting rather than thermoplastic, the curing process of this formulation is said to be irreversible and permanent. There is no dependence on the evaporation of moisture or solvents, and the cured area is totally protected against water, alkalies, mild acids and many other reagents by the formation of a waterproof membrane.

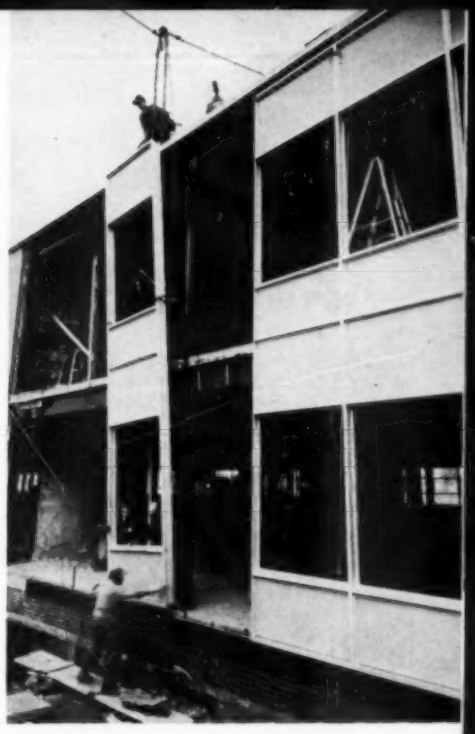
Permagile technicians point out that Uniweld's adhesion to brick, stone, cinder block, gypsum block and other commonly used materials is excellent. The only requirement is that the surface be reasonably clean and free of oil, grease or loose particles. Chipping, notching and roughening of the base surface are unnecessary—as are keys, lugs, anchors and other devices now used to hold new concrete to old.

Mixing equal portions of Uniweld's two components starts the curing cycle. A thin coating of the mixture is applied to the old cement surface by roller, brush or spray, and the fresh concrete is poured directly over this approximately 15 minutes later.

In applications such as surfacing or resurfacing a wall, the use of Uniweld eliminates the need for wire lath. In addition, because strength of the surface layer is not dependent on its thickness, significant savings in materials can be obtained in applications such as resurfacing heavy-duty plant floors or pouring fill on a slab to provide flush surface despite variations in thickness of finished flooring material.

Technician inspects sample in which a top concrete layer (darker color) has been permanently welded to base of cured concrete.

Adhesive Bonding of Curtain Wall Panels



Architectural acceptance of bonded sandwich panels for curtain walls is based on the fact that they provide large flat distortion-free surfaces, and have a proven ability to carry stresses resulting from wind loads and temperature differentials. Since both these qualities are totally dependent upon an adhesive, the proper selection and use of this component is a factor of prime importance and necessitates controlled laboratory testing.

Considered from the point of view of their thermal properties, there are two basic classes of adhesives from which to choose. The thermoplastic variety are usually a rubber or neoprene base compound and set by solvent evaporation. Generally speaking, they react to high temperatures by softening. In addition, they tend to creep under static loads.

Thermosetting adhesives are composed of high molecular weight polymers and set through a chemical reaction which is triggered by the use of catalysts and heat. As a rule, thermosetting bonds develop high strengths and do not soften on exposure to heat. They are highly creep resistant under load at elevated temperatures.

Structurally sound panels can be made from either type of adhesive, but the thermoplastic variety's inherent tendency to creep is a factor which must be given serious consideration. It is a good idea to select only those adhesives capable of functioning under the combined influence of loads and thermal movement.

For example, in the manufacture of Weldwood Curtain Wall Panels, a proprietary thermosetting compound is used which has been formulated to cope with all of the severe demands of this application. Specifically, the adhesive must meet the following qualifications: it must adhere to a variety of metals, particularly while exposed to water and vapor; it must have no harmful effects on the faces or core; it must be able to develop high bond strengths; and it must carry sustained loads at elevated temperatures without creeping.

In addition, the adhesive selected should be one substantially unaffected by the complex of severe conditions imposed by the weather, and should be an adhesive formulated for use with a specific core material.

Though the selection of the proper adhesive is extremely important, it is well to remember that even the best adhesive can give no assurance of a properly bonded panel unless sound bonding techniques are employed. Weldwood panels are bonded at elevated temperatures while the metal face material is expanded. While in this expanded condition, the faces become firmly anchored to the core by the adhesive.

Laboratory Testing

Extensive laboratory tests conducted by the United States Plywood Corp. have provided tangible evidence that the adhesive type and technique selected result in an adhesive bond of exceptional qualities. For example, room temperature tension tests of specimens bonded with a half-inch single lap have consistently produced shearing failures of approximately 1600 psi in porcelain enamel steel. These failures have always occurred in the glass coating and not in the adhesive.

Similar tests with metals such as aluminum have demonstrated adhesive shear values in the range of 2000 to 3000 psi. There has been no evidence of creep on single lap, metal to metal adhesive specimens when subjected to a shearing stress of 200 psi at a temperature of 160°F. for a period of 1200 hours.

Water has always been a persistent problem in building construction. It remains a serious factor to be reckoned with even though in recent times we have departed from the more traditional construction materials and are now building walls with bonded sandwich panels.

Completely dry walls do not exist. Inevitably, water will penetrate through joints which are not properly sealed, or which open as a result of building movement. A second source of moisture is from water vapor diffusion into the wall cavity where, under certain conditions, it condenses.

A factory sealed edge detail is essential if moisture is to be prevented from entering into the panel interior. However, in no case is this sealed edge to be considered as a substitute for a waterproof adhesive or a waterproof core.

A number of critical demands are imposed upon the panel edge sealant used in Weldwood panels. Essentially the material selected was one which had satisfactory adhesive and aging qualities, and high water resistance.

In lab tests of sealed edge specimens, the sealant compound maintained satisfactory adhesion to a porcelain surface even when immersed in water for 775 days. The sealant showed no evidence of deterioration.

When exposed to a temperature of −20°F. the sealant did not become brittle, and there was no sign of embrittlement, deterioration, or flow when it was subjected to a temperature of 220°F. for 500 hours.

Adhesives Viscosimetry

By E. PATRICK McGUIRE
United Paste & Glue, Inc., New York, N. Y.

An investigation of the character and quality of viscosity with a discussion of viscosimeters and their ability to do the job at hand

Some adhesives technologists will conveniently divide the causes for most adhesive failure into improper setting characteristics and incorrect viscosity range. Although this dichotomy is too patently simple for such a complex occurrence, it nevertheless acknowledges the indispensable role viscosity plays in adhesive technology. There exists a multitude of methods and theories surrounding adhesive viscosity, but before examining these let us first investigate the character and quality of viscosity.

Nature of Viscosity

We notice that if a liquid is agitated the induced movement radiates gradually from the point of agitation to the furthermost confines of the liquid's container. The internal resistance of the different liquid fractions acting at variant velocities creates a "viscous" property to the substance. This resistance constitutes one of the most essential elements of viscosity.

The elemental theories governing viscosimetry were first postulated by Newton in his "Principia." These principals are the basis and foundation for present day viscosimetry.

As we have mentioned, different layers within a liquid exert a resistance against the movement of each other. In order for this "viscosity" to be measured we must be aware of the force required to exceed this resistance. Newton's postulants reveal that the force required to sustain this variance in velocity is proportional to the gradient of velocity.

Poiseuille in 1846 performed a series of experiments which provided a foundation for modern viscosity measurement. It is in recognition of this work that the term "poise" originated as a measure of dynamic viscosity. The term "centipoise" (cp.) refers of course to one hundreth of a poise and has become to a large degree an internationally accepted measure of viscosity.

Much of the initial work in viscosimetry was performed using capillary viscosimeters. Poiseuille experimented with this type of apparatus and arrived at an equation to quantitatively express capillary flow. This expression refined to modern usage would be stated:

$$v = \frac{pr^4}{8ln}$$

Concerning the flow of liquids through a tube; where v equals the quantity discharged in a measured time interval, l the tube length, n the coefficient of viscosity, p the difference in pressure between opposite ends of the tube, and r the radius of the tube.

It should be noted that this work was performed using water as the test liquid and applies accurately to simple liquids. Colloidal dispersions and complex solutions are not so docile in their acceptance of this law.

Couette Method

The Frenchman Couette in 1890 discovered yet another method of measuring this resistance termed "viscosity". Couette based his method on a system employing two cylinders; one placed inside the other. One cylinder rotated while the other remained stationary. Employing equations originally suggested by Stokes(1845), Couette was able to ascertain the resistance force between the coaxial cylinders, and thus the viscosity of the fluid in which these cylinders were immersed.

MacMichael Viscosimeter

Ostwald Fenske

Zahn Cup-Type

In considering the probability of a fluid adhering to a proffered viscosimetric hypothesis we must first establish whether the fluid is Newtonian or non-Newtonian in nature. With adhesives this poses a consistent problem. Unfortunately, most aqueous adhesives typified by products formulated from macromolecular substances such as starch and dextrine, do not conform rigidly to most laws of viscosity. These materials are non-Newtonian fluids and we cannot correctly expect rigid adherence to these standards. As we have pointed out most viscosimetric laws were prepared using simple fluids as their test cases.

If we plot the flow curves of Newtonian versus non-Newtonian liquids we shall observe the former functions as nearly a straight line while the latter is represented by a slight arc. Colloidal solutions often show differences in the velocity gradient dependent on their aging characteristics and the mechanical stresses exerted on them. In emulsion viscosity measurement the apparent viscosity may also alter as the shear of the liquid alters.

There are at least a dozen basic methods employed to measure aqueous adhesive viscosity. Fundamentally, however, we must consider these devices of two general types. The first type measures viscosity by passing a measured volume of liquid through a tube or orifice and recording the critical passage time. The second type measures the internal resistance the liquid offers to the movement of a sphere, disk, paddle or cylinder immersed in the liquid. Some of these types are represented in standard industrial viscosimeters. In other instances, because of the peculiar fluid characteristics of the adhesive, special techniques have been devised. The writer will attempt to outline briefly some of the principles and apparatus being employed by the producers of aqueous adhesives.

Capillary and Orifice Types

Capillary viscosimeters, although the instruments in longest general usage, are still among the most popular types in use by the chemical profession. This popularity does not however extend in equal proportion to the fraternity of adhesive technologists. The reasons are obvious. Capillary viscosimetry is best suited to thin simple fluids exhibiting little cohesiveness or thixotrophy.

In this method a subject liquid is forced, usually by its own gravity, through a capillary tube. By a correlation of the pressure, rate of flow, and the dimensions of the tube, a viscosity determination is effected. This method has certain weak points if we are to employ it in adhesive measurement. As the material flows through the tube in a gravity arrangement the head will be altered resulting in a variant pressure exerted against the fluid.

If the tube is short in length, turbulence will occur and the validity and reproducibility of the results will be questionable. This turbulence is due to a change in the flow pattern of the liquid. In capillary viscosimeters with short tube lengths or with increased diameters the liquid particles no longer move in straight lines but rather they oscillate and wobble about producing turbulence.

The tendency to turbulence in this instance is inversely proportional to viscosity. Capillary viscosimetry allows us to obtain almost direct poise values for the liquid being examined. Although primarily concerned with dynamic viscosity, we may ultimately wish a measure of kinematic viscosity which is the dividend of the viscosity divided by the density of the material.

Low viscosity solutions of starches, dextrines, and gums may be measured with various type capillary viscosimeters. Dilute solutions of animal glue are also recorded with this type of apparatus. The equipment is simple and inexpensive. Viscosity determinations may also be performed rapidly. However, this method is most applicable and feasible on fluids with low viscosity properties. In the consideration of most adhesive formulations this method would be impractical because of the small tube diameters involved and the consequent lengthy time interval involved in such a determination.

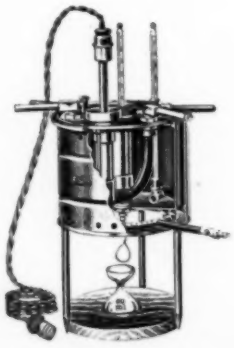
Short tube or orifice viscosimeters can better meet the needs of standard industrial adhesives. The Engler, Saybolt-Furol and other instruments of this type are excellent examples of this classification. These instruments record viscosity in seconds and this value is then convertible to poise readings.

Stormer Viscosimeter

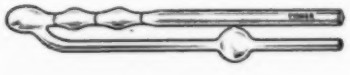
This instrument employs a rotational principle. The unit of time required for a paddle, prong, or cylinder to complete a predetermined number of revolutions is recorded. This paddle is immersed in the test liquid and driven by a definite weight. The weight is adjustable to compensate for variant extremes in the viscosity range i.e.; very heavy liquids would require a proprotionately heavier gram load to drive the rotating paddle.

Viscosity is recorded in seconds but a conversion table to centipoise values is easily constructed. One of the values of this instrument lies in its ability to measure a wide range of materials since it functions independent from the test liquids' specific gravity.

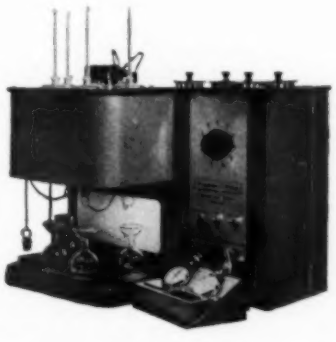
The Stormer Viscosimeter can safely be used on a wide range of aqueous adhesives. In practice, however, some segments of the industry seem to favor it for the measurement of resin emulsion viscosity more than any other single type. It is also employed to record starch fluidities with the use of temperature stabilizing baths. The Stormer Viscosimeter is at times a bit slow for use in rapid control lab procedures. This instrument nevertheless represents a worthwhile addition to any adhesive laboratory.



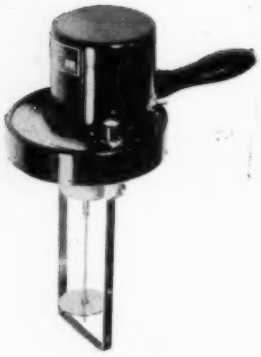
Saybolt Single-Tube



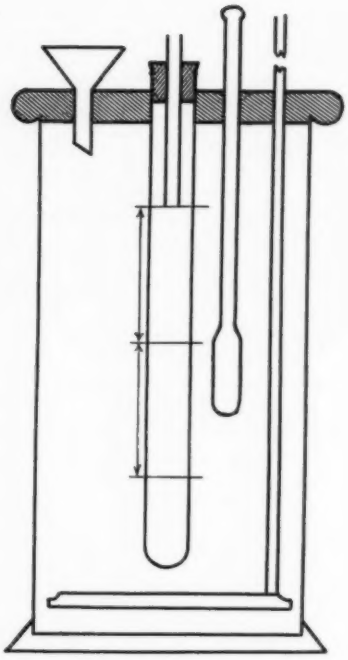
Cannon-Fenske



ITAG Saybolt



Brookfield Synchro-Lectric



Gibson-Jacobs

Fisher Electroviscosimeter

Gardner-Parks Mobilometer

The Gardner Mobilometer is primarily a production or control type instrument. A vertical cylinder is filled with the test liquid to a specified mark and the plunger with close wall tolerances is inserted and allowed with a measured load to descend through the liquid. As the plunger descends, the subject liquid is forced through the tolerance between the plunger edge and the cylinder wall. The time interval required for the weight-loaded plunger to fall is measured and recorded. The plunger may be considered a disk and as it falls along a vertical axis a constant velocity inversely proportional to the viscositv of the liquid is reached (Stokes' Law).

The Gardner Mobilometer is finding much wider use today as some firms adopt it as a control instrument in testing adhesive purchases. It has excellent application potential in pastes and semi-pasty materials although it can, of course, be easily utilized with low viscosity materials. The writer has some misgivings about any firm adopting this type instrument as a single uncorrelated source of viscosity measurement. In combination with other viscosimetric means it can provide a valuable adjunct to your adhesive testing arrangement.

In the employment of this instrument on thixotropic vegetable or resin pastes you will at times have difficulty in obtaining accurately reproducible results. This is not to imply that it is an inaccurate instrument, but rather reflects on the inherent difficulties present in the measurement of all thixotropic materials.

For utilization in higher viscosity ranges the plunger disk is often perforated with a set number of holes. This allows the plunger a free fall in heavy substances. Pastes and semi-pasty materials would employ this arrangement. With some adhesives it may even be necessary to exceed the standard temperature in order to obtain free plunger fall. Through the calibration of a Gardner Mobilometer with a known viscosity standard you may obtain direct dynamic viscosity on the adhesives tested. This instrument, like all viscosimetric apparatus, must be kept thoroughly clean if it is to produce dependable results.

MacMichael Viscosimeter

The measurement of torque exerted on a suspended disk provides the basis for this type of viscosimeter. A wire attached to the disk suspended in a liquid conveys the measurement of this torque. The cup or container of adhesive is rotated by a turnable at a constant 20 rpm by a gear motor. As this cup rotates, the liquid exerts a torque on the suspended disk. This action in turn twists the connecting wire and the amount of torque is recorded by a connected pointer on a degree scale. This instrument is calibrated with a degree scale of 300 gradients. Viscosity on this instrument is usually referred to in terms of MacMichael degrees and no attempt is made to convert this value to a poise reading.

This instrument can also be used with a specifically designed cylinder rather than a disk. This procedure would be applicable in those fluids with low viscosity ranges.

These viscosimeters have a wide application potential but their use in the aqueous adhesive field has often been reserved for the measurement of heavy cohesive pastes. High viscosity vegetable label pastes as well as casein-based iceproof label pastes have been measured on this apparatus. Occasionally, the viscosity ranges of heavy resin pastes are also determined on this apparatus.

This instrument is fairly easy for a laboratory technician to operate. It suffers mainly from the tendency to express values obtained on it in terms of MacMichael degrees rather than in the desired standard of poise values. For many control laboratories this objection may be a minor one since they are primarily concerned with comparative standards.

Even the most casual study of this viscosimeter will reveal certain obstacles to high accuracy measurement. For one thing, the observer will note the disk sets up spiral rather than circular flow lines in the liquid as rotation occurs. There is also evidence that the density of the test material exerts an influence on disk deflection. These and such other occasional factors such as turbulence make precise correction to poise values difficult for the working adhesive chemist.

The MacMichael Viscosimeter offers a wide latitude of possible measurement. This viscosimeter may accurately record viscosities of up to 2,500 poises by the utilization of a separate series of connecting wires.

Brookfield Viscosimeter

The Brookfield Viscosimeter also employs a modification of Couette's principles to measure the torque exerted on a spindle inserted in the

test liquid and rotated at a constant speed. This electro-mechanical arrangement is very convenient to the tester. It allows him to determine viscosities nearly directly from an indicator dial. The instrument is supplied with spindles of varying disk diameters, each conveniently marked as to the proper insertion level.

This instrument is extremely versatile. The writer has used these viscosimeters for a number of years with very little difficulty in obtaining reproducible results. The only major problem encountered with this device may occur in those cases where the line current powering the rotational motor is subject to appreciable deviation. As with other instruments of this type the spindles must be kept scrupulously clean. The spindles for accurate measurement should be wiped dry before insertion into the test liquid. Occasional diminishing of accuracy may sometimes be traced to either temperature differences, dirty spindles, or failure to securely attach the spindle.

If the author was forced to choose a single instrument type in measuring aqueous adhesives, the Brookfield would be his choice.

Falling Sphere Viscosimeters

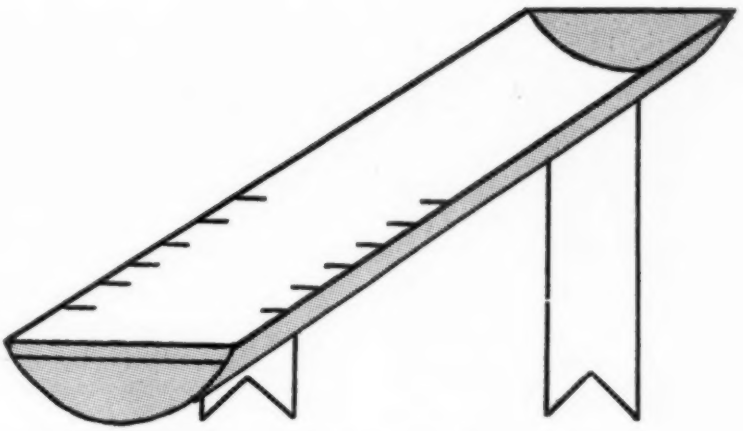
There exist several variations on this method but they have a single basic principle upon which they are dependent. The falling sphere viscosimeter usually employs a precise glass cylinder and a finely machined steel ball. In this method the steel ball (sphere) is allowed to fall vertically through the test liquid and the duration of time is recorded as it passes through a pre-determined observation space. In essence, we employ Stokes' Law to determine the rate or velocity of the fall. The sphere falls under the influence of gravity until it acquires a constant velocity. This principle is in agreement with Stokes' Law which is represented as:

$$V = \frac{2\ ga^2(d_1 - d_2)}{9n}$$

where a is the radius of the sphere, d_1 and d_2 the densities of the sphere and the medium respectively, n the coefficient of viscosity.

Gas Bubble Method

This method is generally more suited to clear solvent cements and lacquers than to aqueous adhesives. The test unit is usually very simple and many times home made in origin.



A rudimentary flow table for paste viscosity measurement.

The apparatus may consist of a series of long glass tubes which are solid or sealed at one end. The opposite end is stoppered. A range of fluids, their viscosities pre-determined, are placed in the tubes and the tubes are tightly stoppered. Care is taken to leave a small air space at the top of each tube. The air space in each tube is the same. These tubes act as the comparison standards for this device.

When this test rack containing the standard tubes is inverted, the air space at the top of each tube becomes a bubble flowing to the opposite end of the tube. In the measurement of a particular unknown adhesive the subject liquid is placed in a tube identical with the standard tubes and a similar air space is left. By comparison with tubes of rated viscosity this adhesive is matched to its correct viscosity value.

Flow Tables

Many of the flow tables in use today in this field are either homemade or modifications of existing devices. It would take a considerable space of text to describe them all. They do, however, employ a very similar principle. These tables are generally restricted to the measurement of various vegetable pastes, their use being prompted by the inability of most viscosimetric apparatus to cope with materials of these viscosity dimensions. An illustration of this type is contained in the accompanying illustration.

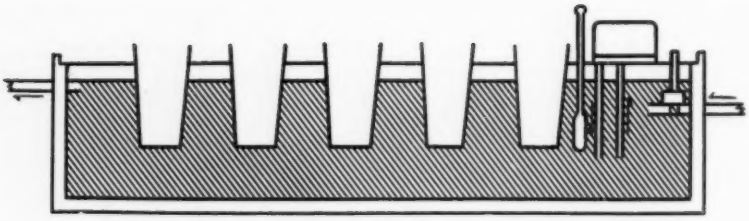
In the illustrated viscosimeter, a cup of paste is prepared taking care to work the paste into all portions of the cup. The excess paste is struck off flush with the top of the cup. The cup is then turned quickly on its edge and the paste allowed to flow out of the cup and down the inclined trough. A measurement of the time required for the paste to flow to a predetermined point in the trough is recorded. This value for the paste is usually expressed either in seconds or the procedure is reversed with a standard time limit being employed and the value of the paste being expressed in centimeters of flow. There is seldom any effort on the part of technicians using this method to equate the values received into poise relationships.

As we have noted there are other variations of this principle but, essentially, a flow table is precisely what its name implies. In considering the validity of this method it must be remembered that the nature of paste consumption is such that in many instances the customer does not notice or quibble about a variance of a few poises in paste viscosity.

Hand Viscosimetric Rating

Hand rating is a simple, rather crude, method of rating viscosities on aqueous adhesives. This method is restricted to control laboratories where a large volume of viscosity measurements must be made in a minimum of time.

The essential elements of this system are a constant temperature bath and a set of oil samples of known viscosity values. The oil samples provide the standards which are used for viscosity comparison. These standards are placed in similar cups or beakers and allowed to remain in the constant temperature bath until they assume the bath temperature. Wooden stirring rods are inserted. To rate the viscosity of an adhesive using this system it is necessary to



A constant temperature bath arrangement for manual viscosity determinations.

first chill the material down to the designated bath temperature.

When the temperature of the testing sample is the same as that of the standards a comparison may be made. A similar stirring rod is inserted into the test adhesive and a series of hand stirring comparisons are carried out until the observer is able to place the test sample close to a particular standard in viscosity characteristics. This method produces a value of usually within five poises of the actual viscosity designation.

This instrument in my opinion, is somewhat hazardous even in the hands of experienced technicians. When inexperienced personnel are first introduced to this system there is likely to be chaos unless their ratings are checked by experienced personnel. Since this method leans heavily on manual dexterity there is likely to be conflict even among experienced observers. The reader may regard this method as hopelessly archaic but the fact remains that thousands of tons of adhesives have been processed using just the system described above.

Thixotrophy and Build-Up

The effect of thixotrophy or false viscosity is felt sharply in dealing with aqueous adhesives. This attribute of some aqueous adhesive formulations can make precise viscosity measurement a frustrating and sometimes futile task.

Thixotrophy is often mistakenly confused with paste-back or viscosity build-up. In reality we must consider thixotrophy as a separate action inherently different in origin than viscosity build-up. Through examination of truly thixotropic materials we will observe that after severe agitation these materials return to the general range of their original viscosity. Grades that have truly pasted back will seldom return to their original viscosity despite severe agitation.

It is characteristic of nearly all aqueous adhesives that they increase somewhat in viscosity on standing. This build-up is attributable to many factors and its cause and extent is nearly always dependent on the peculiar ingredients of the formula being considered. This type adhesive is for the most part colloidal and does have some tendency to thicken upon aging.

This thickening process is especially prevalent in those formulations relying heavily on borax and sodium hydroxide. Some formulations of this type may increase anywhere from 10 to 40 per cent in viscosity. The swelling of the polysaccharide granule, the delayed effect of borate or hydroxy solubility and a host of other factors may contribute to this viscosity increase. Seldom will mere agitation return these products to the viscosity they registered during the draw-off stage.

Unmodified Vinyl Resins

Unmodified vinyl resin adhesives exhibit little viscosity build-up. The modification of these resin adhesives with plasticizers, chlorinated hydrocarbons, polyvinyl alcohol, mineral extenders, etc. radically alters this docile viscosity behavior. It is not always easy to evaluate the direct effect these additives have on the viscosity stability of a particular resin. Many modifiers do not establish straight line relationships in their alteration effect.

The observer will note that the addition of certain chlorinated hydrocarbons and other solvent types will at first produce a thinning effect in the emulsion adhesive and, as the solvent concentration becomes overpowering, the adhesive will change course rapidly and begin to thicken. Some adhesives of the above type may require several days to attain a true viscosity. In this case, the solvent addition and the consequent thickening may be related to an incompatibility of the two systems.

Resin Emulsion Adhesives

Resin emulsion adhesives containing polyvinyl alcohol as an extender or modifier are noteworthy in their viscosity build-up characteristics. There is, of course, a relationship between the hydrolysis percentage of the selected alcohol and its viscosity stability. Fully hydrolized alcohols, particuarly those in the higher viscosity ranges, often produce extended thickening when included in resin adhesive formulations. Polyvinyl alcohol producers have markedly improved the "jel-resistance" of this type of alcohol in recent years to the point where it no longer poses a serious problem in adhesive formulation.

Much of the difference in viscosity noted in compounded animal glue may be traced to such simple factors as insolubilization and plain evaporation. A typical cake of flexible glue produced at 65 per cent solids may well lose 5 per cent of its moisture upon one month's standing in a dry area. This loss is especially pronounced when the product is packed in fibre drums or cartons and not individually wrapped. Although there has been much work done on viscosity measurement and standardization for dry animal glues the fact remains that many manufacturers produce a compounded cake or jel type of animal based adhesive with very little in the way of viscosity control. This practice is not necesarily dangerous to the manufacturer since they correctly assume that the consumer intends to add *dilution* water to his own viscosity preference.

Viscosity Standardization

It should now be evident that the adhesives industry does possess a wide range of methods and values associated with viscosimetry. Incident with the many values assignable to an adhesive's viscosity is also a certain amount of confusion. The writer does not presume to propose any single standard or single method in a field so obviously varied. However, it would behoove us all to discuss this adhesive property in a single value such as poises or centipoises. This is a term that both the customer and the novice of the industry can be expected to understand.

Viscosimetry can be and is a very interesting facet of adhesive technology. Besides being merely interesting it is vitally important to all concerned with adhesives. This single property of an adhesive can often assume the decisive role in determining whether or not an adhesive is consumer accepted. A reliable and constructive viscosity measurement program is paramount to both consumer and manufacturer alike.

Assembling Delicate Instruments with Adhesives

Use of a single adhesive has brought under control three potential production line bottlenecks at the Universal Transistor Products Corp., Westbury, N. Y.

One of the necessary by-products of the atomic age is the extraordinary amount of instrumentation required to measure and control atomic radiation. Among the more interesting devices in this catagory is Universal's dosimeter pen, a compact instrument which though worn or carried like any fountain pen measures the total gamma radiation to which the bearer is exposed over any given period of time.

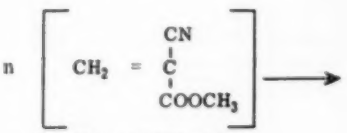
When Universal undertook the design of its dosimeter pen last fall, however, several factors delayed its production on a commercial scale. Chief among these was the bonding of the sensitive element, a fine quartz fiber, to its mountings.

Fragile Nature of Fiber

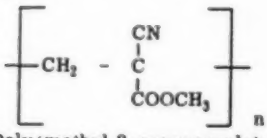
Because of the fragile nature of the fiber, the use of an adhesive was indicated. However, production experts felt that there was nothing available which provided the requisite combination of characteristics. The latter included: ability to bond quartz fiber to aluminum, rapid set time and sufficient conductivity.

All of these requirements were met with the introduction of Eastman 910 Adhesive. This product has as its main component a reactive material which exhibits exceptional bonding action. Known chemically as methyl 2-cyanoacrylate, the unusual potential of this material was first discovered several years ago when a series of vinyl-type monomers were being synthesized in the Research Laboratories of Tennessee Eastman Co., Kingsport, Tenn.

The chemical structure of 910 adhesive and the polymerization reaction which occurs during bond formation may be shown as:



Methyl 2-cyanoacrylate



Poly(methyl 2-cyanoacrylate)

This chemical reaction takes place very readily, especially in the presence of minute traces of moisture. The unset adhesive, however, may be exposed to the atmosphere for as much as several hours without polymerizing or hardening. Nevertheless, when the adhesive is spread or pressed into a thin film between two surfaces, bond formation is almost immediate.

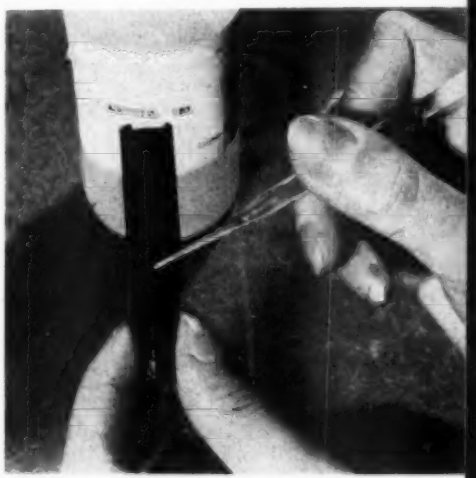
At Universal, Eastman 910 Adhesive is used to assemble the dosimeter's sensitive element by cementing a quartz fiber to two pips on an aluminum wire. During another production stage, the lens system of the "pen" is pre-focused and cemented, again with 910, at the end of one of the device's barrel sections. A drop of the adhesive brings about a rapid-setting and permanent bond between the plastic lens mount and the plastic pen barrel.

In the final assembly of each unit, the adhesive is used once again to bond the two internal barrel sections of the dosimeter. In all these operations, Universal has found that the adhesive sets fully within one minute, which is just sufficient time to adjust the placement of the assembled items.

Dosimeter pens are used extensively by personnel working with any kind of radiation materials in industrial laboratories, hospitals, universities and reactor installations. Accumulated radiation exposure is indicated on a scale which is read through an eye piece at one end. In this way, the individual wearing the instrument is alerted when safety limits are approached.

Quartz fiber supported on a Y-shaped holder is bonded to an aluminum wire.

Pre-focused lens system in plastic mount is cemented to one end of a barrel section.



In final assembly, the internal barrel sections of dosimeter are bonded together.

A Symposium

Adhesives: Technology and Markets

The three talks presented here were originally given as part of a symposium presented at the meeting of the Chemical Market Research Association held in St. Paul, November 12-13, 1958. Complete details on the meeting are given elsewhere in this issue. Taken as a unit, these talks provide an excellent survey of both the present and potential contribution of the adhesives industry to the over-all industrial picture. Because of the importance and authoritative nature of the material, the talks are reproduced here in their entirety.

What Are Adhesives?

By RICHARD F. BLOMQUIST
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Forest Service
U.S. Dept. of Agriculture

Current usage defines an adhesive as a substance capable of holding materials together by surface attachment. This term "adhesive" is now considered as a general term that includes such other materials as cements, glues, mucilages and pastes. The term "glue" is commonly used for adhesives in the wood industry.

Adhesives are classified in many ways. Some of these classifications are based on whether they are solids, liquids or films; whether they will develop strength at normal room temperatures or at elevated temperatures; whether they are intended for bonding paper, wood, metal or plastics; and whether they are for industrial or household use. They are often also commonly classified according to the chemical composition of their base constituents.

Adhesives have been known since early Egyptian days, as records show that King Tut had glued wood chests and other furniture buried with him in his famous tomb. Actually, their use probably goes back even further. perhaps to some caveman who discovered that partially cooked meat stuck to his fingers in the days before knives and forks and Emily Post. More recently we note that glued wood furniture, plywood, and gummed paper envelopes, tape, and labels, have become common in our lifetimes. These have been important starts but the Age of Adhesives is just beginning.

Why, we may ask then, has this use of adhesives and bonding techniques been expanding recently? First, there are the large number of new base components being developed by the chemical industry, particularly thousands of polymers, and the new knowledge in tailor making new polymers for special uses such as adhesives.

Increase in Knowledge

Next is the great increase in basic knowledge of the bonding process. What factors in this process must be controlled? We have learned that the preparation of adherends for bonding, mixing and spreading the adhesive, open or closed assemblies, temperature-time-pressure relations, and reconditioning are all important factors. Also important is a better understanding of the basic nature of adhesion, which has been a lively subject now for five successive Gordon Research Conferences; an appreciation of the cohesive properties of the adhesive layer in a joint; and increased knowledge of the fundamental engineering properties involved in designing joints suitable for adhesive bonding.

At the same time, adhesive manufacturers have developed technical service staffs to adequately instruct new users in the proper use of their adhesives, to prescribe adhesives and bonding procedures for specific end products, and to help in troubleshooting when necessary. The user helped himself by finally recognizing that he needs such technical service and that he must follow specific instructions for each new bonding operation. Better quality control in production of adhesives and in the bonding processes has also been of great importance.

Finally, the requirements of mod-

"Current usage defines an adhesive as a substance capable of hold-materials together by surface attachment."

ern warfare and the supersonic and space age have accelerated tremendously the need for bonded products of fabulous requirements. The fact that the B-58 supersonic bomber or a new missile is largely constructed of adhesive-bonded metals and plastics has given much favorable publicity and confidence in bonded constructions, as has the layman's personal good experience as a consumer of homes built of exterior plywood, of veneered furniture, and of bonded brake and clutch linings. Thus, the public is generally ready to accept adhesive-bonded products and not consider them merely as cheap and shoddy substitutes pasted together.

We might now consider the question of why should we use adhesive bonding rather than other conventional methods of attachments, such as by the use of nails, screws, rivets, soldering, or welding. The advantages of adhesive bonding include the following:

(1) The joining together of certain materials that are difficult or impossible to attach by other methods, such as bonding paper labels to cans or bottles.

(2) Economical and efficient bonding of small pieces of adherends into larger pieces. For example, the joining of many small pieces of wood into larger panels or beams contributes greatly to more efficient utilization of the available timber resources.

(3) Production of smoother surfaces and contours by the elimination of rivets and mechanical fastenings. Results of such adhesive applications are the smoother aerodynamic surfaces required in aircraft and the longer wear made possible in bonded clutch and brake facings by eliminating rivets.

(4) The more efficient and uniform distribution of stresses from one member of an assembly to another, without the concentration of stresses that are encountered in and around bolt holes and rivets.

(5) More efficient design of many entirely new composite articles by bonding together a number of separate materials in prearranged patterns based on good engineering practices.

(6) Less chance of corrosion between materials of dissimilar nature, such as between two different metals, where galvanic action might be otherwise encountered in direct metal-to-metal contact.

(7) Better sealing action for gases and liquids, as in the fabrication of wood boats or metal aircraft tanks.

At the same time we laud adhesives, we recognize they have certain limitations. One of these is that an adhesive that has good adhesion for one type of surface may not bond well to another type of surface. Also, one adhesive may be convenient to use in one production process, but inconvenient in another. This requires the use of a rather large number of adhesive formulations, each specifically tailored for a given application.

The performance of any adhesive will depend on several factors. First, is the joint properly designed to take advantage of adhesive bonding? This involves consideration of mechanical stresses likely to be exerted on the joint, because of its design, by the relative thermal expansion and contraction of the adherends in service, and by the mechanical properties of the adherends themselves.

For example, it is not yet practical to bond the two end-grain surfaces of wood in a straight butt joint where strength is important because the stresses, when such a bonded piece is normally used, are likely to be greater than the level of strength that can be obtained to such end-grain surfaces. A bonded lap joint or a scarf joint would be superior to such a butt joint.

"The public is generally ready to accept adhesive bonded products and not consider them merely as cheap and shoddy substitutes pasted together."

The next factor in determining joint performance concerns whether the proper adhesive was selected for the job. Then, too, was the adhesive used under the proper conditions? This emphasizes the need for adequate quality control. We recognize therefore that bond quality is the responsibility of both the adhesive manufacturer and of the user.

The adhesive user is generally concerned with five factors in his selection of an adhesive for any given use. First is the nature of the materials being bonded. Obviously the adhesive must adhere to each adherend surface. Next, there is a matter of what type of joint is to be fabricated and what are the requirements of this bond as regards the geometry of the specimen, the types of stresses likely to be exerted, and the types of materials being bonded.

The next question concerns the limitations of the bonding process. Is equipment available for heating the joint to develop strength, or must it be done at normal room temperatures? Is it an on-the-job type of application, such as the bonding of acoustical tile to a ceiling, or is it a process for which fairly elaborate bonding equipment can be developed and fabricated? There must also be a consideration of the permanence required of the bond in service. Finally, cost of the adhesive and of the adhesive bonding process is usually of primary importance to the user.

As far as the adhesive industry itself is concerned, adhesives could be divided into two groups that are based largely upon the type of market in which these adhesive materials are sold.

Household Adhesives

These are adhesives that are formulated primarily for small package sales. They are sold through numerous local retail outlets, such as variety stores, hobby stores and hardware stores. They are of particular interest to the home-workshop enthusiast and to the housewife for numerous repairs. These adhesives are normally formulated in a ready-to-use package, or packaged for easy mixing.

Convenience is one of the most important requirements, along with good shelf life. Cost per pound of the adhesive components themselves is less important because of the relatively large cost of packaging and merchandising that is added to the original cost of the base adhesive. Such adhesives generally must be formulated for foolproof bonding under a variety of rather poorly controlled conditions. Household adhesives are not generally required to produce bonds of consistently high quality and they are normally used for nonstructural applications.

Industrial Adhesives

These adhesives are intended for industrial adhesive bonding applications that vary from a simple operation, such as the high-speed bonding of labels on bottles or cans, to the production of a relatively few complex aircraft sandwich panels. These panels, made of such metals

as stainless steel or titanium, are now often designed for service at high temperatures and where retention of high strength is critical, but where cost may be of much less immediate importance than is a high level of performance. Industrial adhesives are usually formulated for rather specific end uses, and are sold in individual lots from one gallon up through drums and tank-car quantities. The sale of such adhesives usually also involves the furnishing of a considerable amount of technical service in their use.

> ***"The sale . . . of adhesives usually . . . involves the furnishing of a considerable amount of technical service . . ."***

Industrial adhesives could actually be further broken down into those that are formulated ready to use, either in liquid form or in the form of a tape to be inserted in the bond, and those that were sold in bulk, to be mixed by the user at the time of use. Examples of the ready-to-use form include numerous liquid adhesives and pastes used in the paper-bonding industries, phenol-resin film glues sold for bonding thin veneers of wood for aircraft and boat plywood, and special unsupported or supported tape adhesives now used for bonding brake linings and metal sandwich panels for aircraft.

Examples of adhesive components sold in bulk form, to be mixed by the adhesive user, include the soybean glues sold for the West Coast softwood-plywood industry, and a variety of adhesives of a proprietary nature which have been developed over a period of years by specific users for their own products. In this latter case, users prefer to buy base materials and mix them either according to formulas of their own development or according to formulas furnished by the supplier of the basic raw materials.

As a prelude to consideration of the principal components of adhesives, we might consider the several mechanisms by which adhesives develop strength in joints. Perhaps the most familiar one is drying or loss of solvent, as in the setting of pastes, mucilages and rubber cements. Heat may be used to speed the drying or solvent loss or this may take place at normal air temperatures. Perhaps next most familiar is pressure-sensitive action, as illustrated by certain well-known tapes in which the actual adhesive is formulated to have good immediate adhesion and still have sufficient immediate cohesive strength to withstand loads and stresses involved.

Another important mechanism is cooling of hot or molten adhesives, as in the familiar hot hide glues for woodworking and a variety of hot-melt adhesives used in packaging, book binding, and labeling. Last, but very important, are the chemical reactions involved in converting thermosetting resins of low molecular weight into fully cured, strong and durable polymers in the joint.

As chemical manufacturers, you are naturally interested in where and for what purpose your products are likely to be used in adhesives. Adhesive components include not only the resins or nonresin bases that contribute the principal adhesive action, but also solvents and thinners, catalysts, hardeners, and setting agents designed to produce the desired setting action.

Also important are modifiers, including plasticizers; fortifiers, such as other resins; monomers or reactive diluents, such as styrene, allyl glycidyl ether, or diallyl phthalate; extenders, such as cereal flours or blood, to reduce costs and still perhaps contribute some adhesive action; fillers, such as nutshell flours or clays, added to improve spreading properties or thermal dimensional properties; and carriers, such as glass or textile fabrics, to support adhesive films in tape form.

Basic Components

The basic components from which adhesives are formulated may be either of natural or synthetic origin, and the naturally occurring materials may include those from animal, vegetable, or mineral origin. Naturally, the older types of adhesives were based on materials from nature, whereas the newer types of adhesives generally have been formulated from the variety of synthetic-polymeric materials which have been made available by the chemical industry in the last 20 years or so.

In all probability, the utilization of the newer synthetic materials will increase in the future at the expense of some of the naturally occurring materials. However, the low cost, convenience, and generally satisfactory performance experienced in selected applications with adhesives based on the older nonresin material is likely to justify the use of very sizable quantities of these materials for many years to come.

The characteristics of each of the important types of raw adhesive components could be the subject of lengthy discussions. The technology of using each type of component in adhesive formulations is covered by literally thousands of patents, or is kept as a trade secret. Hence, in the following discussion, only very general comments can be made to suggest some of the more important examples of adhesives of each base component.

The most prominent nonresin adhesive components are considered first. For convenience of consideration, we may first divide these into carbohydrate, protein, mineral base and a miscellaneous group.

Carbohydrates

Starch-base adhesives are still widely used in the production of laminated and corrugated fiberboard, in the sealing of envelopes, and to a limited extent in the bonding of hardwood plywood. Starch adhesives were used as the principal veneering glue in the furniture industry before the advent of the newer resin glues. Generally any type of vegetable starch, including corn, tapioca, wheat, or potato, might be made into an adhesive. From a practical standpoint it is desirable to use a form of starch that is uniform from year to year and batch to batch, and which will give a uniformly high-quality product. For this reason, tapioca starch has been preferred for the wood gluing industry, and certain of the corn starches are used in the paper industry. A variation of the starch adhesives are those based on dextrins, which are partial hydrolysis products of the starch itself. Dextrin adhesives are widely used in gummed paper products, such as envelopes and stamps.

Vegetable Gums

The natural gums are essentially water-dispersible polysaccharides, such as from tree exudations. The most important of these natural gums for adhesive applications are gum arabic, gum karaya, and ghatti gum. Gum arabic, for example, is usually sold in powder form and is a safe, simple adhesive for miscellaneous paper products. Certain mucilages are prepared from gum tragacanth and gum bassora, which are not as soluble as gum arabic. These gums are also used as thick-

ening or sizing agents for other adhesive products.

Proteins

These proteins may come from either animal or vegetable sources. Some of the most important are:

Animal Adhesives—Animal or hide adhesives, or glues as they are generally known, are obtained by a cooking process from the hides, bones and sinews left from slaughtering operations and not, as stories suggest, from old race horses. The dry form of glue is isolated by evaporation or spray drying of the solutions. The product is graded primarily on the basis of the jelly strength and viscosity of a standard glue solution in water, the higher grades coming from the hides and the lower grades coming from bone sources. Animal glue is the original cabinetmakers' glue in the woodworking industry and is still widely used in the assembly of furniture. Animal glue is also used as the adhesive in bookbinding, in the manufacture of gummed paper tapes, in the fabrication of paper boxes, and in the fabrication of leather belting and a variety of other leather goods, including luggage.

Fish Glues—These have been the basis for a number of the well-known woodworking and household repair adhesives of years past. The supply of fish glue has been somewhat restricted in recent years by changes in the commercial fishing industry, whereby the fish are normally cleaned at sea and the swimming bladders and other organs from which fish glue was originally derived are discarded at sea. However, newer developments in the skinning of salted fish have kept this industry very much alive. Fish glue is suffering from inroads of liquid animal forms as well as the newer polyvinyl-acetate emulsions.

Casein Adhesives—Casein, the dry protein from milk, is the basis for one of the original highly water-resistant glues developed during World War I days for the fabrication of wooden airplanes. Casein glue, at the present time, finds its largest use in the laminating of large rafters and other laminated timbers for interior applications, an industry which has been growing rapidly since World War II. These rafters are used for churches, supermarkets, gymnasiums, auditoriums, and a variety of other buildings where large, clear spans and an attractive appearance are desirable. Modified casein adhesives are also used on labels for beverage bottles, where resistance to ice cold water is required.

Blood Glues—These are based primarily on dry, soluble whole blood. The development of these glues goes back to World War I days when these glues were developed for the gluing of highly weather-resistant plywood for exterior service in wooden airplanes. However, these glues were not adequate in long-term durability, compared to the phenolic and other resin glues, and passed out of the picture for a time. Now, however, the blood glues have been introduced either as extenders for phenol-resin glues, in which case the dry, soluble whole blood is somewhat fortified by the addition of phenol resin in a hot-press glue, or more recently as a straight blood glue from dry, soluble whole blood. Such straight blood glues are now finding increasing use as cold-press plywood glues in the Douglas-fir plywood industry.

Soybean Adhesives—The chief vegetable protein in adhesives is the soybean protein, also used as a feed supplement, and isolated from the residue left from the solvent extraction of oils from soybeans. Soybean adhesives are used primarily for gluing the interior-type softwood plywoods on the West Coast. These glues were formulated originally in a manner very similar to the casein woodworking glues, and are still very much in the picture in this large-volume production of interior-type softwood plywood. Their use in this industry has been under considerable competition from the extended types of phenol-resin glues, which are more adaptable for hot-press operations in the larger production plants where hot-press equipment is available. Soybean glues and glues based on combinations of soybean with blood and other natural proteins are of particular interest in plants that do not have hot-press equipment.

Adhesives from Mineral Sources

Sodium silicate is by far the most important of the mineral bases for adhesives. This has been used for many years as an adhesive for fiberboards and other paper products, particularly because of its relatively low cost and because of the fact that solutions change in viscosity quite rapidly with a change in the moisture content. Joints made with these silicate adhesives are not normally as strong as those made with animal or protein glues, but are quite adequate for bonding the liners to corrugating medium in continuous production of fiberboard. These adhesives are of particular concern where a combination of fast setting, low cost, and moderate strength and permanence is required, such as in the bonding of materials of such relatively low strength as paper.

Magnesium oxychloride and Portland cement are also used in industrial adhesives, particularly for binding ceramic materials.

Miscellaneous Nonresin Components

Natural Resins—Shellac and rosin are components of certain adhesives. They are commonly used to impart special properties, such as tackiness, to other bases for adhesives, and rosin is used as an extender for resins in adhesives. Shellac is used as a hot-melt adhesive in stick form, such as in laboratory sealing cements.

Asphalt-Base Adhesives — Asphalts, either from natural sources or from the petroleum industry, are widely used both in water-emulsion forms and in solvent "cut back" dispersions for low-cost adhesives. One typical example is in the formulation of mastic adhesives for bonding various types of floor tile to concrete subfloors. These are generally low-strength adhesives, which are required only to hold the floor tile in place under normal traffic, and to have enough moisture resistance to resist separation due to condensation of moisture on the floor or penetration of moisture through the slab.

Increasing interest in the one-story houses built on concrete slabs has been an important factor in increasing the markets for this type of adhesive. Such adhesives must have good working properties to permit bonding on the job with no pressure other than the weight of normal traffic. Asphalt formulations are also used as adhesives for bonding paper, as in the convolute winding of cardboard tubes for table salt cartons. Here the asphalt is intended to serve both as an adhesive and as a partial moisture barrier.

Ceramic Adhesives—The current need for structural adhesives for metals where high-temperature service is required, as in the new supersonic military planes and missiles, has focused attention on inorganic-base adhesives as replacements for the organic adhesives. These ceramic adhesives are still in the experimental stages but some already show promise, particularly those based on the conventional frits used in the

porcelainized metal industry. Because of their natural brittleness, these ceramic adhesives will need considerable study and development to make practical structural adhesives, and their high curing temperatures may also be a serious limitation.

Adhesives from Synthetic Resins

The introduction of synthetic resins has unquestionably made possible enormous strides in the adhesives industry. These resins can be made more uniform in quality than natural raw materials and can be tailor-made for specific uses. In addition, many of the resins are much more durable than nonresinous materials and provide new types of adhesives of great and reliable permanence. The wide variety of new polymeric materials makes a discussion of this subject rather complicated. Suffice it to say the field of synthetic resins of interest to the adhesive industry can be divided into the two main classes: (1) those of thermoplastic resins, which can be softened and hardened reversibly over and over again by raising and lowering the temperature; and (2) the thermosetting resins, which cure or harden by undergoing an irreversible chemical reaction to form an infusible and insoluble cured resin in the adhesive bond. Some of these individual resins are used as the main components of adhesives for certain purposes, and other adhesives are formulated from a combination of two or more of these different resins, as well as other additives.

The most important of the thermosetting resins for adhesive formulation are those based on phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, resorcinol-formaldehyde, and the epoxy resins, such as those derived from bisphenol and epichlorohydrin. One important advantage of these thermosetting resins is the fact that, since they harden by undergoing a chemical reaction, their curing rates can be controlled over a considerable range by use of catalysts and by temperature variations, making them adaptable to a variety of industrial bonding processes.

Some of the most important of the thermoplastic resins include the polyvinyl acetate, polyvinyl alcohol, polyvinyl butyral, polyvinyl formal, acrylate and methacrylate esters, cellulose nitrate and other cellulose esters. In addition, polyamides and saturated polyesters, as well as unsaturated polyesters, are used as adhesive bases. The synthetic rubbers of interest in adhesives include neoprene, butadiene-styrene, and butadiene-acrylonitrile. Polysulfide rubbers are also used for certain adhesives.

One of the earliest applications of synthetic resins for adhesives was in the development of wood glues for water-resistant plywood. These developments began in Europe, and were introduced into the United States in the middle 1930's, first as phenol-formaldehyde resin glues and soon after as urea-formaldehyde resin glues. These resins immediately offered distinct advantages over the older woodworking glues, based on naturally occurring materials, in increased production through the use of heat and catalysts to speed the thermosetting curing reaction, and in much improved durability under more severe conditions.

It might be noted, however, that acceptance of these new adhesives was slow because they had different handling properties than the older familiar glues. They smelled differently, were hard to clean up, and the ordinary workman just wouldn't bother to learn how to use them for best results. Often the adhesive manufacturer didn't do the necessary research and evaluation to know how to best apply them to the woodworking operations. This merely indicates the problems in introducing any new product and emphasizes the need for technical service and education of prospective customers.

"World War II gave great impetus to the acceptance of synthetic resin adhesives."

World War II gave a great impetus to the acceptance of the synthetic-resin adhesives in the wood industry and to the development of improved bonding techniques. This was because the military agencies suddenly needed a variety of wood airplanes, gliders, boats, and truck bodies to meet severe outdoor service, and the resin adhesives were the logical answer. The furniture and plywood producers had to take these war contracts to stay in business and had to use these glues. After the early problems due to lack of training and experience, these plants were able to use the resin adhesives successfully and many of them never went back to the nonresin adhesives for peacetime production.

Soon after the successful use of synthetic-resin wood adhesives was underway, development of the adhesive bonding processes for metal to wood were undertaken; this naturally continued to grow into the applications involving bonding metal to metal, and the bonding of various types of plastic materials. As was previously indicated, much of the impetus for the broader use of resin adhesives in the last few years, and much of the confidence in adhesive-bonded constructions, has probably resulted from the increasing use of such adhesive-bonded construction in critical parts in connection with military items.

A good example of this is the B-58 bomber of the Air Force, developed by Convair, which utilizes large areas of adhesive-bonded metal-face metal-honeycomb and plastic-honeycomb sandwich constructions. Requirements of the synthetic-resin adhesives for such application, particularly in aircraft, have resulted in the development of special high-temperature-resistant adhesives, based on combinations of phenol and epoxy resin and other combinations, and the stimulation of considerable amount of basic research on development of new polymers for improved heat resistance.

Synthetic-Resin Adhesives

Phenol Resins—These resins, produced by condensation of phenol with formaldehyde (or of aldehydes, such as furfural, and cresols instead of phenol), are supplied as solutions, powders, or impregnated paper films. They are normally cured at 275°F. or higher. Undoubtedly, the largest single application for phenol-resin adhesives is in the softwood plywood industry, where these glues are used exclusively for the manufacture of exterior-type Douglas-fir and other softwood plywood.

This industry has become highly mechanized with large multiple-opening hot presses, equipped with automatic loading and unloading equipment for high-speed production. In recent years there has been an increasing trend toward extension of the phenol-resin glue with cheaper materials, such as ground bark, residue from furfural manufacture, and dry, soluble whole blood, to produce lower cost glues for interior-type softwood plywood. This has made significant inroads in

the market for soybean and other protein-type glues, normally used for interior plywood.

Another version of the phenol-resin glues is the acid-curing type, originally developed as a casting resin, but which has been used to some extent for gluing wood and other materials at room temperatures or slightly higher. Phenol resins also are a very important component of the structural metal-bonding adhesives in which the phenol resin is modified with thermoplastic resin, such as polyvinyl butyral, or with various synthetic rubbers or epoxy resins.

Resorcinol Resins—Resins condensed from resorcinol and formaldehyde have much the same properties as phenol resins, except that they are capable of being cured at 70°F. or higher and thus don't require hot-press equipment. These glues were developed during World War II, when the need was for durable high-strength ribs, keels, and other members for some of the smaller naval vessels, such as landing craft and minesweepers and for wood airplanes and gliders. The techniques and knowledge developed during that period with the use of resorcinol-resin glues, and later the phenol-resorcinol resin glues, now permit the laminating of a variety of timbers of different sizes.

Typical Applications

Typical applications are for bridge timbers, railroad crossarms, truck body parts, and agricultural implements, as well as for laminates in buildings exposed to the more severe weathering conditions and in the ribs, keels, and other members of wood boats. Indeed, these glue lines, like those with phenol resins, provide higher durability than the wood itself; this has resulted in the treatment of the wood with preservatives to raise its performance to that of the durable glue lines.

Urea Resins—Resins formed by the condensation of urea and formaldehyde are widely used, particularly in the bonding of the interior types of hardwood plywood. This plywood is used extensively in the furniture industry as well as in the manufacture of flush doors and various types of architectural paneling. For this purpose, the resin is often extended with varying amounts of wheat flour, or other cereal flour extenders, to reduce the glue-line costs. Urea resins are quite versatile adhesives in the wood industry, since they can be formulated for curing either at room temperature or in hot presses, or with high-frequency heating, such as for edge-gluing lumber.

Melamine Resins—These are condensed from melamine and formaldehyde. The principal use of melamine resins as adhesives, at the present time, is in combination with urea resins. A typical formulation is equal weights of the two resins. These are hot-setting resins normally cured at 240° to 260°F. and used primarily for making the more durable types of hardwood plywood for severe service, such as in boats, exterior doors, and certain types of wood floor tile. Their principal advantages over the phenol and resorcinol resins are their lack of color and lower curing temperatures.

"One principal advantage of epoxy resin adhesives is their ability to bond adequately a wide variety of materials."

Epoxy Resins—Epoxy resins are among the newer types of resin adhesives developed since World War II. The principal type at present is from condensation of bisphenol A and epichlorohydrin. These epoxy resins are formulated into adhesives by adding fillers, and are usually cured with an amine curing agent. They can be formulated for curing at or near room temperatures, but more commonly they are cured at around temperatures of 200°F. One principal advantage of epoxy-resin adhesives is their ability to bond adequately to quite a wide variety of materials, including metals, plastics, glass, and wood. At the present time their principal application appears to be in the fabrication of aircraft sandwich, and other structural and semi-structural applications in the aircraft industry.

They are also used, however, for assembly of a wide variety of other articles, including bonding of reinforced glass plastics, and are beginning to appear in tubes for home workshop use. It can be expected that this type of adhesive will increase considerably in volume, particularly if the price can be reduced.

One important variation of the epoxy resins is their modification with other materials, of which a special polyamide resin, derived from unsaturated acids, is of particular interest. Other modifying agents are polysulfide rubbers, used to impart greater flexibility, and phenol resins used to improve the heat resistance.

Thermoplastic Resins

Vinyl Resins—These include polyvinyl acetate, polyvinyl alcohol, and polyvinyl acetals, particularly the formal and the butyral. These resins are commonly used in solutions in organic solvents, although polyvinyl acetate in emulsion form has become a very prominent adhesive in both the wood and paper industries because of its fast-setting characteristics and general convenience of use. In recent years, there has been a distinct trend toward the emulsion polymerization of copolymer resins, mainly polyvinyl acetate, with other monomers that have not been publicly identified.

Polyvinyl acetate emulsions for gluing wood appeared on the market soon after World War II; thus, they were in competition with animal glue, which was in short supply at that time. These emulsion adhesives have the advantage of being ready to use at normal room temperatures, and are rather fast setting compared to the conventional woodworking glues. They set by partial loss of moisture to a porous substance such as wood.

They have taken over a sizable portion of the market from animal glues for applications such as edge-gluing lumber and for assembling of furniture, as with dowel and mortise-and-tenon joints, in the assembly of chair rungs and similar parts. They appear to be quite promising for these assembly operations although there is still some question about their adequacy for edge-gluing solid lumber because of their limited creep resistance, particularly when moist or warm.

These adhesives are not highly moisture resistant or suitable for outdoor service. Recently, there has been a trend toward modifying the vinyl emulsion with other thermosetting resins, such as phenol or urea resins. Such combinations might well be the most promising of the newer adhesives in the wood industry, but much needs to be learned about their properties.

Polyvinyl alcohol is available in three adhesive grades: low, medium, and high acetate content. The low-acetate grade is used in paper and textile adhesives; the medium-acetate

grade is used in remoistenable adhesives and heat-seal coatings; and the high-acetate grade is used in solution adhesives.

Polyvinyl butyral is the most important component of safety-glass laminates, where a sheet of polyvinyl butyral is used directly as a middle laminate between the glass sheets, without a separate adhesive, in a hot-melt bonding process. Polyvinyl butyral and polyvinyl formal adhesives have also been used in solvent solutions, where they develop strength merely by loss of solvent. Polyvinyl butyral and polyvinyl formal are important components of high-strength metal-bonding adhesives in which these thermoplastic resins are combined with phenol resin to form hot-setting adhesives. They have been widely used in the fabrication of aircraft sandwich panels, but this use is definitely declining because of their limited heat resistance. They are being replaced by phenol-epoxy adhesives for the more critical military aircraft applications where such heat resistance is needed.

Acrylic Resins—These resins are commonly used in solution form but are also available in emulsion form. Their principal application is in bonding glass and clear plastics, where light transmission is an important factor along with flexibility and strength.

Polyester Resins—These are primarily the unsaturated polyester resins from glycols and maleic anhydride. These materials are also used, of course, for the production of reinforced glass-fabric laminates. The distinction between their use as an adhesive and as a laminating resin is not clear cut. The unsaturated polyester resins can be used as 100 per cent-reactive adhesives for bonding the cured plastic laminates to themselves, although they do not bond well to wood or metals. Saturated polyester resins are used as adhesives in conjunction with diisocyanates to form polyurethanes. Such polyurethane adhesives are not yet well established in commercial applications.

Cellulose Esters and Ethers—The most important cellulose derivative used in adhesives at present is cellulose nitrate, familiar to many in solvent form as a convenient household cement for model plane fabrication and repairs. The same adhesives are used industrially for the fabrication of shoes, particularly ladies' shoes, where they are used as temporary bonding agents for component parts before final stitching or nailing. In some shoes the adhesive bond is the principal means of joining.

These adhesives are also used for bonding a variety of textile materials, such as in patching, and in assembly of linings for collars and cuffs. Cellulose acetate solutions are used much like the nitrocellulose cements. Some of the cellulose derivatives, such as carboxymethyl cellulose, are used quite extensively in the formulation of other types of adhesives in order to provide certain properties. Ethyl cellulose is used to toughen some heat-sealing adhesives and to impart low-temperature flexibility and strength.

Synthetic Rubber Adhesives—Adhesives based on solutions of rubbers in organic solvents have been used for many years as in the familiar tire-patching cements. They are also used in the assembly of a wide variety of mechanical rubber goods. In addition to natural rubber, the synthetic rubbers of interest are neoprene, butadiene-styrene, and butadiene-acrylonitrile and polysulfides. Adhesives based on these rubbers may be simple solutions in organic solvents, or incorporated with vulcanizing or curing agents and fillers.

The solvent types of rubber cements are used for a wide variety of applications, including the assembly of rubberized fabrics, such as tents, liferafts, rubber boots, shoes, tires, tubes, and for repair operations of rubber goods. Neoprene adhesives in solvent solution have been widely used in recent years for bonding plastic laminates to wood and to steel in contact bond operations. One of the newer developments here is a continuous bonding operation that involves spray application of the adhesive, drying under infrared lamps, and pressing under instantaneous nip roll pressure. This type of application has caught the eye of certain branches of the wood industry where a rapid and continuous bonding operation would be of great value.

If some of the limitations of the present neoprene-type contact cements can be improved, particularly to raise the general level of strength and reduce creep properties while maintaining good aging characteristics over a long period of time, these adhesives might well be expected to find an important market in certain phases of the wood-bonding operations. Their cost is a questionable limitation at the present time.

A number of the rubber-type adhesives, including those made from reclaimed rubber and those of neoprene, have been finding increasing use for bonding thin floor tiles to concrete subfloors, and in some cases, to wood subfloors. Rubbers of different types are also used in formulations of other types of adhesives, particularly in some of the pressure-sensitive tape formulations.

As has been previously indicated, there has been a very definite trend in recent years towards formulating adhesives based on combinations of two or more different resins, or combinations of resins with nonresin materials. Outstanding examples of this have been the development of practical, high-strength and economical bonding processes for critical applications, such as aluminum faces to aluminum honeycomb cores for aircraft components that include the primary wing surfaces and control surfaces of military aircraft. The bonding of helicopter rotor blades is another outstanding example of where the high-strength metal-bonding adhesives have greatly improved the fatigue resistance of joints over that characteristic of other methods of fastening, therefore making such metal rotor blades practical. These metal-bonding adhesives are combinations, generally, of phenol resin with epoxy, polyvinyl butyral, or synthetic rubbers.

More recently, combinations of urea-melamine resins have been used for plywood combinations of urea resins and polyvinyl acetate for special wood-bonding operations, and combinations of thermoplastic resins or synthetic rubbers in emulsion form with casein glues. These latter combinations have been used for short-press cycles at room temperature for wood bonding, such as in the fabrication of flush doors. In addition to these few examples, there are literally hundreds of thousands of combinations of resins and nonresins.

As has been previously indicated, the adhesive industry is one in which it is generally necessary to prescribe or formulate a specific adhesive for a given end use. This is necessary in order to achieve the proper adhesion to the adherends involved, to provide the necessary working characteristics to make adhesive bonding practical in the plant operations involved, and provide the level of cost and permanence required of the joint. We can certainly expect that future efforts to develop new adhesives will involve more of the combinations of many of these individual resins that have been mentioned, as well as use of the newer polymers and other materials being continually developed.

Symposium on Adhesives:

Where and How Adhesives Are Used

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There is scarcely an industry or an article of commerce existing today that isn't dependent upon an adhesive in one or more stages of its operation or use. This may be as simple as affixing a postage stamp to an envelope, or labeling a bottle of your favorite beverage, or as complicated as the bonding of the structural members of an aircraft. Many new recent developments in adhesive uses have been publicized with such dramatic sensationalism, that all too frequently the ordinary uses to which adhesives are put daily are overlooked.

Although it is difficult to properly classify these adhesive consuming industries in logical categories, one suitable listing by generalized products is as follows:

(1) Packaging and Paper Converting.
(2) Wood Products and Wood Converting.
(3) Metal and Plastic Converting.
(4) Household or Consumer.

There may naturally be considerable overlapping of these classifications since both wood and paper may be fabricated into a package, or metal, plastic and wood combined to produce a wall panel of a building. However, this grouping is somewhat a natural one since adhesive manufacturers tend to specialize in producing adhesives for only one of these groups. There are understandably some exceptions.

In the packaging and paper converting industries, a wide variety of containers and packages are involved. Manufacturers who convert paper or paperboard, or films of metal foils and plastics into such packages as bags, cartons, envelopes, tubes, cans, and shipping containers fall into this group. Publishers of books and magazines are considered paper converters. Packaging adhesives may be used in the fabrication, sealing or closing, or labeling of any of these articles. Paper may be laminated into several plies to produce board which is further cut and fabricated into a box or carton.

Paper and plastic film bags are produced in a wide variety of sizes and shapes. Most of these bags require an adhesive to produce a tube from one or more layers of suitable material. These adhesives are generally referred to as "seam" adhesives; a "bottom" paste is required to form the bottom, thus converting the tube into a bag. Multi-wall paper shipping bags are rapidly replacing textile and cloth bags for the packaging of many dry powders and chemicals. Interliners of plastic, waxed or treated paper used to improve water resistance and moisture vapor transmission of the bag may require specific adhesives which bond to these surfaces.

A short trip through a super market will quickly and dramatically illustrate the wide use of cartons, bags, bottles, pouches, cans, overwraps for packaging today's food and consumer goods. Practically every one of these containers required an adhesive. If not for its construction, closure, or labeling, then for the shipping case in which it was transported.

> ***". . . adhesives manufacturers tend to specialize in producing adhesives."***

Labeling adhesives must bond to metal, glass, and plastic surfaces and at high speeds. Wrap-around labels extensively used on fruit and vegetable cans are occasionally applied at the rate of 600 to 700 per minute! Billions of such cans are labeled annually, and there is no place here for a slow sticking adhesive.

Beer bottle label adhesive must withstand refrigeration temperatures, rapid changes in humidity, or complete submersion in iced water, yet be readily removable in the soaker when returned for refilling. In 1957, over 15 billion bottles were labeled and required close to 20 million pounds of adhesive for labeling and casing.

The forming, packaging, and shipping of cigarettes may require the use of seven or more different adhesives: (1) The tube or seam adhesive; (2) The cork or filter tip; (3) The hard or soft pack; (4) The foil laminated inner liner; (5) The tax stamp adhesive; (6) The cellophane and tear strip adhesive; (7) The carton adhesive; (8) The shipping case adhesive.

In addition to producing bonds to these specific surfaces, these adhesives must meet requirements of taste, odor, color, flexibility, and speed of set. Above all, they must have proper physical properties to perform without trouble in high speed machines.

Four or five different adhesives may be required in the manufacture of a book. An envelope manufacturer may stock five or six different adhesives for his work. One carton manufacturer lists 37 "approved" adhesives on his purchasing records. Food packers require adhesives for such uses as sealing a paper milk bottle, sealing and over-wrapping a carton of cake mix, labeling a bottle of ketchup, sealing a bag of potato chips or peanuts, or protecting the flavor of coffee by gluing a disc under the jar cover. Most of the new glamorous and spectacular blister and skin packs, boilable-cooked-in the bag packages, decorative and protective film and foil laminations, self-sealing wrappers and packages would not be possible without specific packaging adhesives.

A recent survey of packaging adhesives[1] reported the annual sales

of all types of packaging adhesives are somewhere around 115 million dollars, covering over a billion pounds. These figures are based on Department of Commerce figures and trade estimates. An interesting observation was pointed out that according to these figures, only 7/10 per cent of the 15 billion dollar total cost of packaging America's products is spent for packaging adhesives—unsung, underpaid heroes!

Although wood was one of the first construction materials available to man, it has been only in the past few decades that it has really come into its own. Adhesive bonding of wood to wood, wood to metal, and wood to plastic has been responsible to a large degree. Plywood was practically unknown before the turn of the century. The development of faster setting, reliable bonding, water and moisture resisting adhesives have made plywood an important and useful material of construction.

"In 1957, over 250 million pounds of dry adhesives were consumed by the plywood industry."

In 1957, over 250 million pounds of dry adhesives were consumed by the plywood industry. This produced 5½ billion square feet of softwood plywood and about 400 million square feet of hardwood plywood. About one-half of this adhesive was manufactured from phenolic resins while the balance consisted of urea formaldehyde, soya protein, casein, etc. Exterior grade plywood finds wide spread use for marine construction, for building siding and panels, for concrete forms, and many other uses requiring outstanding resistance to weather and the elements.

With the limited availability of decorative hardwoods like bird's-eye maple, walnut, birch, and mahogany, most of today's furniture manufacturers rely on veneer rather than solid woods. Substantial quantities of synthetic resin adhesives are required for these veneering processes. They also play an important role in combining wood with plastic laminates for table and counter tops. Cold bonding of wood to plastics and metal is a reality, and the modern cabinet maker has discarded his old hot glue pot. Well over 20 million pounds of adhesives are used by the furniture and cabinet making industries annually.

Laminated wood structural timbers are finding increasingly wide use in the construction of many types of building. These laminated timbers are helping to solve the difficult problem of finding single pieces of timber large or strong enough to meet rigid building specifications. Adhesives used in their construction resist the dimensional changes in wood caused by variations in temperature and humidity extremes. It is claimed that properly constructed laminated beams are more fire resistant than steel, and that they retain their strength at higher temperatures than steel. Casein, resorcinol, and phenol-resorcinol resin base adhesives are most commonly used for laminations of this type. Particle board used 75 million pounds of resin in 1957.

Metal and plastic converting industries undoubtedly represent the largest and most diversified outlets for adhesives. Into this category fall the large automotive, aircraft, and marine users, the building and construction trades, and the light metal and plastic users such as appliance, electronic, and hard goods manufacturers. A recent issue of *Dunn's Review*[2] points out some of the more spectacular uses to which modern adhesives are being put.

Classic Epoxy Uses

The modern classic use of epoxy and other synthetic resin structural adhesives in aircraft and honeycomb structures is an example. It was explained that from four to ten pounds of adhesives are currently being used in every antomobile produced. These uses include application of insulation and sound deadening materials, the bonding of accessories and small metal parts, and the application of rubber and plastic trim units.

Chrysler bonds the brake lining and clutch face plates with adhesives. With a predicted output of 5 to 5½ million cars in 1959, a potential market of from 30 to 35 million pounds of adhesive exists. If plastic bodies gain wide use in automotive construction, adhesives will undoubtedly be used in fantastic quantities.

For aircraft construction where light weight, uniform distribution of stresses and high mechanical strength is required, structural adhesives have produced some outstanding accomplishments. Resinous pitches, rosin and tars, formerly so essential to marine construction that they are referred to as naval stores, have given way to modern synthetic resin adhesives, binders, and caulking compounds. Navalcraft made entirely of wood and adhesives were developed during World War II to eliminate detection by magnetic mines and metallic detectors. Fiberglas hulls and decks or seats also require bonding.

Although a modern skyscraper constructed entirely of metal, plaster, and glue may not be a reality today, modern construction and building require huge quantities of adhesives. From the bonding of the ceiling insulation tile to the laying of the floor tile of rubber, linoleum, or plastic, many adhesives are necessary. Ceramic tiles once set only with inorganic cements are now commonly placed with organic base adhesives. Curtain walls which can be rapidly erected or replaced rely on adhesives for their construction and placement. Adhesives are replacing nails in dry wall construction.

The widespread use of plastic laminates and panels helps to insure the continued use of synthetic adhesives. Panels taking advantage of cellular or honeycomb cores sandwiched between light weight metal or plastic skins save considerable weight in a building and consume substantial quantities of adhesives. Cellulose or mineral insulation bats may use plastic or aluminum foil barriers all glued with adhesives. Flush doors are produced by bonding plywood to a wood frame which contains a lattice structure.

Estimated consumption of adhesives used by the building or construction trades is extremely difficult to obtain since these products are sold both through retail outlets and direct to the consumer in sizes from two-ounce tubes to 55-gallon drums. They are sold under general terms of cements, adhesives, glues, mastics, binders, sealants, and under such interesting trade names as Grip-Tight, Grab-Fast, Stick-um-goo, Floor-Tight, Sta-Bond, etc. However, best trade estimates indicate that the volume may run well over 50 million dollars annually.

Consumer Appeal

Trade names bring to mind their appeal to the public consumer and his interest in household or consumer adhesives. The first household adhesives to appear on the market were generally the liquid fish glues, then the natural gum mucelages, through the nitro-cellulose "Duco" type cements, and then on to the

Mend-All iron glues. Today's plastic squeeze bottles containing polyvinyl acetate emulsion adhesives are making substantial inroads on the consumer market.

Hobby and handicraft shops offering wide varieties of model building equipment represent a substantial and growing outlet for adhesives. Molded plastic parts are replacing the soft woods for construction of these models, and organic solvent base resins and cellulose derivative cements are very popular for this type of work. Several epoxy adhesive kits have been placed on the market recently. Small packages of school paste made from organic vegetable bases are still very popular in schools for art work and apparently still appeal to the school children as a mid-morning snack. The "do-it-yourself" philosophy has encouraged many home owners to explore the use of adhesives in and around the home. *Chemical Week* has estimated that the small package consumer market amounts to approximately 15 million dollars annually[3].

Choosing the Form

The choice of the physical form and in many cases the type of raw materials used to manufacture an adhesive is dictated to a large extent by the equipment used for its application. This is particularly true in the packaging field where very high speed equipment of rather exacting design is used for the adhesive application. In addition to adhering the two surfaces involved, the adhesive must have good "machining properties" in order to be considered for the operation in question. They must not throw, foam, cotton, channel, skin, or liver, to use terms which are applied to some of the "machining properties" by machine operators.

Almost without exception, adhesives are applied to surfaces to be bonded in liquid form, either in solution, dispersion, emulsion, or molten form. The solvent may be organic in nature or simply water. Remoistenable and pressure sensitive tapes may appear to be exceptions, but the adhesives are applied to the supporting film in a liquid form. Free film or supported films of thermoplastic resins are deposited from liquid bases prior to their final use, and they become liquid on heating during the bonding stage.

Both free film and supported films of thermosetting or catalyst setting resins also must be cast in liquid form and again become liquid prior to curing to a solid. One novel application of a catalyst setting adhesive is the coating or saturation of glass cloth with a mixture of an epoxy resin and the catalyst. By shipping and storing this supported adhesive film at very low temperatures, the curing action does not take place until it is brought to room or elevated temperatures.

The final choice of adhesive application, if not prescribed by a particular machine designed to do a specific operation, remains pretty much up to the ingenuity of the adhesive engineer or the adhesive consumer. Commonly used methods for applying adhesives are brush or hand tools, roller, spray, plunger, stream, knife coaters, or combinations of these methods.

Fluid or free-flowing adhesives can readily be applied with a paint or glue brush. This method is simple and economical, but it is rather crude for large volume or high speed operations. Many viscous or semi-plastic cements are too heavy to brush in place. Consequently, these may be applied with serrated edged trowels or scrapers.

The most widely used automatic method is a direct transfer from a roller. This may consist of a large roller revolving in a glue pan and by means of scrapers, doctor rolls, or transfer wheels, the amount of adhesive can be metered onto any surface contacting the final roll. This technique is widely used in laminating and package fabrication.

A variation of the direct roller application is the use of the plunger which may transfer the adhesive from a roller directly to the bonding surface. This is useful where a definite pattern of adhesive is desired which may not be possible from a continuous roller and is frequently used in envelope manufacturing and bottle labeling.

Spraying of fluid adhesives is not unlike the spraying of paint or finishes. Where relatively large areas are involved, and where the open time of the adhesive is not too critical, or where components are too large or complicated to pass through a spreader, spraying is very effective. Many organic solvent adhesives can be sprayed in place, part or all of the solvent allowed to evaporate, and contact with the mating surface made with sufficient pressure to insure uniform distribution of the adhesive.

Possible disadvantages of spraying are the lack of control of area covered, the amount applied, and control over the exact loss of solvent. Several application methods involve the use of a stream or controlled metering of the adhesive. There are several types of metering pumps available to apply a continuous bead of adhesive to any flat surface. Bag seams, multiple invoice and office forms, and strips of remoistening adhesives are produced by this method. The use of a nozzle on either a plastic squeeze bottle or caulking gun can deposit adhesives in a well defined area or amount either intermittently or continuously.

Knife-coating techniques are also well suited to adhesive applications. The trowelling of a semi-plastic adhesive is in a sense knife-coating. In laminating continuous sheets of materials, an excess of adhesive can be maintained behind a knife edge. The amount of adhesive applied can be regulated by the adjustment of the knife edge.

Another technique frequently used in winding multi-wall convolute tubes is to completely submerge alternating webs in adhesive, scraping the excess from both surfaces, and making contact with uncoated webs at the mandrel. For small intermittent application, nothing has replaced the effectiveness of the finger.

Modern adhesive technology has kept pace with modern adhesive requirements. Some improvements can be made in methods of applying adhesives, in the development of faster setting and cleaner machining adhesives, and will be in due time.

Since industrial adhesives are generally sold to industrial firms and not the general public, their true value and wide use are not well appreciated or advertised. Most adhesive manufacturers are formulators and not basic manufacturers of their own chemicals or raw materials. Therefore, they represent excellent markets to those who are more basic. Though the average man on the street cannot appreciate what adhesives are doing for him today, chemical manufacturers must surely realize the value of several billion pounds of raw materials which today's adhesives require.

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Symposium on Adhesives:

The Future For Future Adhesives

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There certainly isn't any question but what some of the adhesives existent today, plus some of which we have had but a glimpse of in laboratories across the country, are going to be widely used in what by today's standards are unusual circumstances. The new forms in which adhesive products are available, the new materials and the sometimes unusual combination of materials employed by architects, engineers and designers in the creation of their products, and the improved application techniques for adhesive products all point to their broader use.

But whether or not the Ouija boards and crystal balls to which I have had access were accurate as to just how and where these adhesives will be used, remains to be seen. Perhaps this is an appropriate time to remind you that fortune tellers are often good at merchandising their trade, but it doesn't necessarily follow that merchandising managers, on the other hand, are good fortune tellers.

How Adhesives Compete

Adhesives serve to hold two things together. So do nails, bolts, screws, rivets, spot-welders, string, sewing machines and staples, along with many other devices. For you to let your imagination run free with mine, it is probably necessary that we spend a few minutes talking about the attributes that adhesives possess that entitle them to compete with this rather formidable array of materials that also serve to hold two things together.

First, with respect to the forms or types of adhesives which are available today: there are liquids which are 100 per cent solids; there are liquid adhesives which set when they are deprived of contact with oxygen; and there are materials in film form which, upon the application of heat and pressure, transform themselves into powerful adhesives with thermosetting or thermoplastic properties, depending on their composition.

These are among the newer products on the market today. Double-faced adhesive films wherein one face comprises an adhesive having great affinity to certain surfaces and the opposite face affinity to other surfaces. Metal versus paper honeycomb, for example, is a relatively new product. Contact bond adhesives which are applied to the surface of materials to be bonded together, allowed to dry, but which hold like grim death when the two coated surfaces are bonded to each other, are finding widespread use. There are adhesives available that react and set when exposed to light. There are those that are elastic and those that are rigid, and there is a selection among those that are resistant to a whole range of deteriorating influences such as water, petroleum and ketone solvents, acids and alkalies, sunlight and temperature extremes.

There are adhesives which swell or expand to fill a void when exposed to heat, and there are some that are deliberately conductive so that they can be welded through or so that static electricity can be drained off through them. Conversely, of course, there are products that have insulation values that stop the galvanic action of dissimilar metals or that serve as a weather break against the passage of heat and cold.

The liquids that are 100 per cent solids and the film adhesives which react in the presence of heat and pressure make possible the bonding of such relatively impervious materials as metal, glass, plastics or masonry, either to themselves or to each other. The old problem of drying through evaporation or absorption is completely eliminated.

With two-part products, each part is more or less inert until it is mixed with the other, and then curing or setting occurs by chemical reaction. But there are even variations on that theme. One two-part product appears to be one-part. The catalyst in this product is latent and won't exert its influence toward creating an adhesive bond until it is excited into action by the application of heat.

Application techniques to facilitate the use of adhesive products have generally kept pace with the product development itself. The film adhesives are easily stamped or die-cut to an infinite variety of shapes to match the shapes of the objects to be bonded together. Some of these films are tacky to insure their staying in place until the surfaces to be mated are properly aligned.

Strength Characteristics

The liquid products can be sprayed or trowelled or brushed or roll-coated into place. Some are extruded from hand or power driven guns that offer an endless variety of bead shapes and sizes. Pumps are available to move these products through pipelines to whatever point they are needed on a production line. Proportioning units and guns that will accurately and continuously mix the components of these two-part products in exactly the proper ratio are well along in their development.

Inasmuch as we have already observed that the basic function of an adhesive is to hold two things together, an element of strength is implied. Some discussion regarding the strength characteristics of modern adhesive products is therefore necessary to prepare your imagination for the flight into the wild blue yonder into which, according to the title of this talk, I am expected to take you.

Let us consider two pieces of aircraft aluminum bonded together with one of the film adhesives developed for the aircraft industry. The bond in this case has a shear strength of about 5,000 pounds per square inch. If we were concerned

with a tensile bond instead of one in shear, it is likely that we could expect a strength in the order of 10,000 pounds per square inch. That is a very impressive figure if you consider that a Cadillac Coup de Ville, full of gasoline, oil, water and five passengers, weighs just over 5,000 pounds, and one square inch of this adhesive will support it plus maybe a Volkswagon or two.

By comparison, two pieces of identical metal held together with conventional rivets provides a strength of about 2,000 pounds per square inch.

There is a good reason for this drastic difference in performance and it relates back to one of the basic advantages of an adhesive bond. When two objects are properly adhered together, relatively large areas of each of the objects are intimately mated to each other in such a manner that any stress that tends to pull them apart is uniformly distributed over the whole bonded area. In this way, the entire adhesive mass, and the materials it holds together, team up to resist the destructive force.

Concentration of Stresses

In the case of objects that are riveted, bolted, spot-welded, stapled or sewn, such stresses are concentrated at the point of fastening. Actually, the point of fastening is often the weakest point because the objects have been perforated to accept the rivet or bolt or staple. For example, when cards have been punched and metal prongs used to achieve a mechanical fastening, they can be torn and separated with relative ease. With cards that have been bonded together, an entirely different result is experienced.

Let us quickly review strengths, before going on to the more exciting consideration of what lies before us in the future.

Consider an epoxy resin base product serving the dual purpose of being an adhesive and a void filler which will give strength in the order of 3,200 psi. This product with the latent catalyst will provide metal to metal bonds of about 4,500 psi. A polysulfide polymer base product will provide a bond between glass and aluminum of about 150 psi, yet it will elongate 300 per cent beyond its original dimension, and recover. Contact bond adhesives for holding decorative laminates to plywood and for many other purposes will exert around 1000 pounds per square inch. Some are strong; some are stronger; some are weak. Some are rigid and some are flexible. It pretty much depends on what the customer needs.

Now let's talk awhile about where these products may be used, and what modifications and improvements occur. Let's even try to imagine what new inventions in adhesive development may come about in the future.

First, you must accept the premise that adhesive bonds are often stronger than the objects they hold together and that inherent in that strength is the ability to use lighter weight materials to join dissimilar materials that are not easily joined mechanically. Adhesives help to achieve compactness and greater beauty through the elimination of bolt heads, seams and fastening protuberances. If you will concede that adhesives can be applied quickly by relatively inexpensive mechanical means, and that they frequently serve the multiple function of holding, sealing and insulating—and that there is, even today, a fair selection and control of curing times—I think it is reasonable to expect that we will see them used in some of the following places.

Some of our people, even middle aged ones, believe they will live to see the time that a substantial part of automobile bodies will be adhered or chemically welded with adhesives regardless of whether the bodies are of plastic or metal or combinations of these materials. Some experimental work has already been done to substitute adhesives for welding automotive frames.

> ***". . . a substantial part of automobile bonds will be adhered or chemically welded with adhesives whether the bodies are of plastic or metal . . . "***

It seems logical to us that car manufacturers should borrow a page or two from the aircraft people in bonding hat sections and stiffening channels in such areas as trunk lids, hood sections, turret tops, door panels and fire walls. It would save weight and tend to reduce noise and corrosion. Trim moldings, affixed today by clips that protrude through perforations in the car body, could easily be adhered and a major source of corrosion would be eliminated. The same might be said for the medallions and nameplates and the dashboard gimcracks we all seem to feel are so necessary to automotive beauty.

With strengths of 10,000 pounds per square inch available, the automotive hinges for the hood, the door, the trunk, the gas tank cover and the glove compartment might well be adhered.

If you detect just a small note of wishful thinking in some of my remarks, it isn't entirely accidental. However, it seems to us that the makers of mobile homes and cargo trailers will one day redesign their products to eliminate the hundreds of rivet and bolt holes that exist in them today and that must be plugged with nuts, bolts, rivets and sealers to insure that they will hold together and won't leak.

Marine Applications

In the marine industry, we see much the same thing. If there was ever an object that shouldn't have holes punched in it, it's a boat. Wooden boats can be adhered together and their seams permanently caulked. Certainly, if the B-58 Intercontinental Bomber can be chemically welded with modern day adhesives, it should be within the realm of possibility to do the same with an aluminum rowboat or a canoe. It seems rather logical to form a seamless boat of metal or plastic and one whose exterior surfaces would be entirely free of screw heads or rivet heads to impede its passage through the water. With no seams, there would be no need for caulking, and stiffener ribs, seat fastenings and keel assemblies could be adhered.

A group of our people brainstormed this subject the other day in an effort to help me prepare this talk for you, and some rather fascinating results were obtained. They envisioned the complete assembly of shoes without sewing or nails. Feet must have been a prominent part of that discussion because they came up with the idea of adhesives to mend socks, to replace sewn seams in clothing, to patch and repair fabrics and carpets that today are rewoven. They envision the attachment of buttons with an adhesive instead of thread.

In the appliance industry, there seems to be a most fertile field. The tubs and shells of washing machines and clothes dryers bonded, sealed

and insulated in one operation and the simultaneous bonding, sealing and insulation of refrigeration and air conditioning equipment is not an idle thought or too far-fetched. Some investigation of these possibilities is already under way by people who make these things.

Printed circuitry for electronic equipment is dependent on adhesives and is expected to progress into fields beyond the radio and television uses it has today. One of our fellows came up with the thought that metal foil tapes might be bonded to walls and roofs to serve as radio and TV antenna.

We are being confronted almost daily with ideas and proposals for new uses for adhesives in the construction industry. They are solid, useful ideas. I've heard architects and home builders ask for a completely preformed plastic bathroom that could be transported on a truck, lifted by a crane and neatly dropped into its proper position in a home. They would then connect its plastic outlets to plastic piping by means of —sure, adhesives.

Andy Place of South Bend, Indiana, a most progressive designer and builder of good quality tract homes, has calculated that his job site labor is costing him between nine and ten cents a minute per man, and that labor is being used to cut and pound and fit some 120,000 different items into the house. Just an asphalt shingle roof for an average house requires about 11,000 nails and about 3,500 shingles. So he and other progressive builders are asking that just as many components as possible be pre-prepared, or prefabricated if you will, under factory conditions and with the most modern materials and techniques in order that job site labor can be reduced.

". . . an average house requires about 11,000 nails and about 3500 shingles."

Inasmuch as dry wall or plasterboard panels are reportedly being used in something like 40 per cent of the homes being constructed in the country today, the matter of providing adhesives to adhere these panels to studding and, in doing so, to eliminate the nails which are presently being used and which tend to pop out and disfigure the wall, is a subject of serious consideration. Should adhesives be available that would eliminate the laborious procedure of masking the joints in these dry wall panels with such materials as spackling plaster and paper tapes, another new area of adhesive consumption is revealed.

Expansion joints between masonry slabs, or where masonry or metal forms a joint with other materials, need adhesive materials that will permanently perform the triple function of bonding, sealing and void filling. Similar expansion joints in terraces, driveways and patios need permanent weatherproofing. A substantial start in the development of compounds specifically designed for these purposes has been made.

Roof decks on commercial buildings are commonly installed today with asphaltic compounds which soften and flow in the presence of heat. The tragic fire of the General Motors Hydromatic Plant in Livonia, Michigan, a few years ago was many times worse than it had to be because these materials ignited, flowed and propagated the fire into areas where otherwise it might not have gotten. Fire-resistant adhesives suitable for the bonding of built-up commercial roofs are a necessity and will doubtless be devised to meet conditions of this kind.

One- and Two-Part Compounds

We have briefly examined today one-part and two-part compounds which can be flowed into crevices to perform the dual function of joining and sealing. The plugging of such crevices is a common problem in the plumbing industry and the laborious and time-consuming methods of pounding oakum and melted lead or sulfur into these crevices will doubtless be supplanted one day by adhesive products of a proper composition.

Some of you have doubtless watched how sill plates are fastened to concrete foundations at the time that a house or building is in its initial stages of construction. At the expense of considerable time and effort, metal bolts are imbedded in the concrete slab and the sill plates are then impaled on these bolts in order that there is some place against which to affix the studding. Brief experiments to date indicate these sill plates may well be adhered to the concrete slab at considerable saving in time and labor.

Talk of buildings and houses evokes thoughts of furniture. Manufacturers of wooden furniture, of course, have been major consumers of glue for many years, yet countless yards of textiles are nailed and stapled to these wooden frames. Whether or not suitable adhesives can be devised to provide better economy and greater efficiency for the makers of wooden furniture is unknown, but the market is there. The makers of metal furniture for the office and the home are presently devoted to mechanical fasteners. I think we have already seen that it is logical to believe that adhesives have a rightful place there as well.

Foam Products

So far in our discussion of various adhesive products, we have failed to talk about foam products of one kind or another. Nevertheless, the development of self-generating foams of a polyurethane or polyester base or expandable beads of polyester resin is progressing at a rapid rate. In most instances, these products serve a triple purpose: they adhere well to the surfaces they touch, they provide excellent insulation value and, properly compounded, they can contribute considerable structural value. Sandwich panels utilizing one of these foams as the meat of the sandwich, so to speak, hold forth great promise of widespread use in the construction of buildings, in appliances, in aircraft and missiles, in rail equipment, and in other places too numerous to name.

While this is by no means a full review of the opportunities that seem to exist for adhesive products in the general industry, there are yet other things that are worthy of consideration.

For example, there is a product that is known as "Bull Cement," and the business on it is increasing at a rather steady rate. It used to be that a buyer at a livestock auction had a difficult time identifying the animals that he purchased because there was no sure way of distinguishing one beast from another when they were all milling within a corral. He might buy a bull and end up with a cow, or vice versa. As proof of the fact that there are few problems incapable of solution by the adhesives industry, it was discovered that a gob of "Bull Cement" could be slapped on the flank of an animal with a long-handled brush and that a pasteboard tag with an identifying number could be almost instantly affixed to it.

Today when a cattle buyer buys a Brindle Bull, he marks "No. 23" on his book and at the end of the selling session, he demands that Animal No. 23 be delivered into his possession. If your imaginations are still with me, it certainly must have occurred to you by now that what will work on a Brindle Bull should certainly work as well on pigs or sheep and that, therefore, the future for future adhesives is indeed unlimited.

Improvements and modifications in existing adhesives are necessary and they will occur. Products with higher heat resistance, products with faster setting times and products that are less expensive are necessary if some of the future end uses that we envision for these materials are to evolve. Even more efficient application equipment is required, particularly with respect to two-part compounds where the requirements of accurate proportioning exists. However, as I have already said, these things will come.

With respect to new inventions, it is of course almost impossible to forecast with any accuracy just how these will happen. We are obviously somewhat dependent on our raw material suppliers to invent and devise new materials from which new adhesive products can be made. Likewise, we are stimulated and encouraged to invent solutions to problems which are brought to us by important customers. It should be no secret that much of the progress that has been made in the development of adhesives and coatings for the aircraft industry has been as the result of the demands they have made on adhesive suppliers.

Possibly of most importance is the obvious fact that adhesive manufacturers are completely dependent on the rate at which their products sell and how they compare competitively. In addition, the most progressive members of the industry are constantly concerned with composition and formulation problems, for a large part of the adhesive industry today is still more or less a prescription business. Native inventiveness, technical curiosity and the everlasting drive to be competitively superior is probably the main wellspring from which new adhesive inventions will come.

We find today that most objects must be designed and engineered quite specifically to utilize the full value inherent in present day adhesive products. By and large, adhesive joints which are subjected to stresses that tend to cleave or peel the adhesive bond are weak by comparison with those on which the stresses are exerted in tensile or in shear. This presents our industry with at least a couple of problems.

We have a difficult and big educational job to do within those industries into which adhesives should find their way, and because all objects can't be designed so that stresses are in tensile or in shear, some further product development or invention must be done. It's an interesting challenge and it isn't a frightening one, for if the progress in our industry in the next ten years equals the progress of the last few years, the job will be done.

Neoprene Sealers

Facilitate Engine Production

By switching the adhesive type used in finishing engine cylinder blocks and heads, Pontiac Motor Division of GM has bypassed a troublesome production line snag.

In the manufacture of the above parts, certain openings must be left in rough castings to facilitate the removal of core sand and casting residues. When the blocks are machine finished, the openings are closed up by the insertion of metal core plugs. An adhesive sealer applied to the openings prior to the insertion of the plugs assures a water-tight seal.

When Pontiac put the new automated V-8 engine plant into operation in 1954, a sealer composed of a gum alcohol solution was used. Because of the sticky gummy nature of this material, production line troubles soon followed. Most important of these was a tendency of the applicator orifices to become clogged during operation.

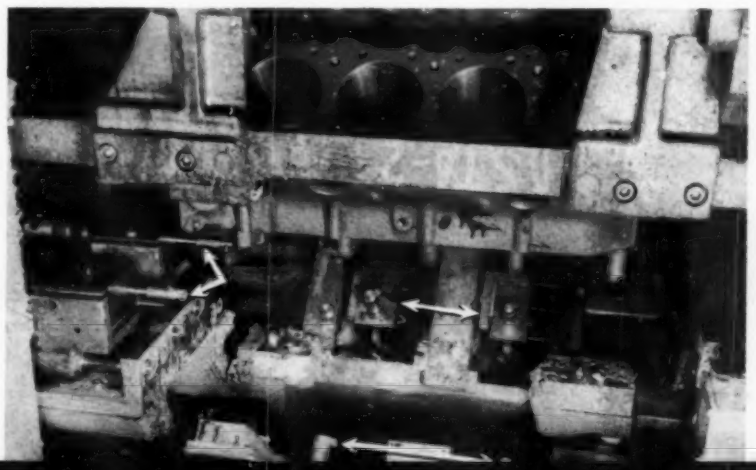
To overcome this condition, a changeover was made to an adhesive sealer which is basically a neoprene emulsion in water. The switch, however, required that an entirely different mechanical applicator be built and adapted to the automation.

In the new setup, the sealer in the automatic applicator is gravity fed from a round overhead reservoir into a hydraulically controlled metering block. From here it is distributed through six feeder lines to the applicator units, one for each core plug hole.

As a cylinder block progresses through the Ingersoll core plug press, the first stop positions the block so that the applicators cycle into the core holes. The applicators then rotate and distribute an even coat of the sealer on the machined surfaces of the holes which contact the plugs. In the next position of the block, the core hole plugs are pressed in. Each air driven applicator is timed to rotate as the metered sealing compound is extruded through a single opening in the applicator head.

The same method of application is used in the Snyder cylinder head core hole plug presses.

Cylinder block in the welch plug press is ready to receive adhesive sealer application. The arrows on the photo indicate the locations of the six automatic applicators.



ASTM Committee D-14 on Adhesives Holds Fall Meeting in Washington

Committee D-14 on Adhesives of the American Society for Testing Materials held its Fall Meeting on October 16 and 17 at the Shoreham Hotel in Washington, D.C. In addition to morning and afternoon sessions of various subcommittees, the meeting featured a general session on D-14 business and a special dinner program.

Guest speaker at the dinner, held on Friday, October 17, was Jack Cowling of the U.S. Naval Research Laboratory. Mr. Cowling's topic was "Luminous Paints for Aircraft." Another special speaker at the Fall Meeting was Dr. Stromberg, National Bureau of Standards, whose talk on the adsorption of polymers from solution was delivered at a meeting of D-14's Subcommittee VII on Research.

The program of standardization reported at the meeting is indicative of the broad applications for adhesives in industry today. For example, the climbing drum peel test for evaluating the strength of aircraft and structural sandwich constructions is ready for presentation to the Society for adoption at the ASTM Annual Meeting in Atlantic City, N.J. (June 21-26, 1959).

Further work in the field of structural adhesives has been the gathering of engineering data to determine the effects of the rate of loading in the Method of Test for Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal) (ASTM Designation: D 1002-53 T). The results of this study will be published in an early edition of the ASTM Bulletin.

New Additions

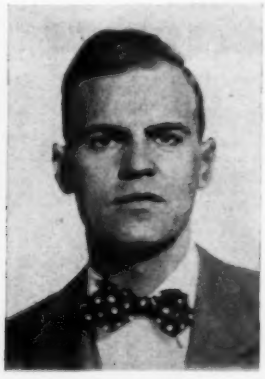
In addition to the existing standards for adhesives for packaging, new 1958 standards added to the list include the Specification for Adhesives for Automatic Machine Labeling of Glass Bottles (ASTM Designation: D 1580-58 T) and two methods to determine bonding permanency and water absorptiveness (D 1581-58 T and D 1584-58 T).

Methods of testing resin base adhesives for non-volatile content and filler content (ASTM Designations: D 1582-58 T and D 1579-58 T) have recently been adopted. A new method to determine the specific gravity and non-volatile content of solvent-type resin adhesives is being prepared for presentation to the Society for adoption.

A test for creep which provides basic data for the determination of safe working stresses has been under development by the committee for many years and will be presented to the Society for adoption in 1959. It is an extremely sensitive index of strength, which may not be a linear function of stress, and has been proved by much experimental work.

The ASTM's Committee D-14 was organized in 1944 and has a continuous record of achievement and progress. Its present membership is 130, a figure which includes representatives of consumers and manufacturers, as well as those having a general interest in the field.

A. A. Marra



W. W. Sederlund

J. E. Rutzler, Jr.

John J. Lamb

Current chairman of the D-14 Committee is Dr. J. E. Rutzler, Jr., Associate Professor of Physical Chemistry, Case Institute of Technology, Cleveland, Ohio. Chairmen serve for four years, and Dr. Rutzler's term expires in 1962.

At the present time, the Committee meets twice a year—the Fall Meeting is held in the East in late October, and the Spring Meeting in the Middle West in early April. The next meeting of the group will be held at the University of Michigan, Ann Arbor, Mich., in April, 1959.

Because of the diverse nature of its activities, Committee D-14 has been organized into 12 subcommittees. The specific interests of these subcommittees and the names of their current chairmen are listed here.

12 Sub-Committees of the ASTM's D-14 Committee

No.	*Title*	*Chairman*	*Affiliation*
I	Strength	D. K. Rider	Bell Telephone Labs.
II	Analytical	G. F. Lipsey	General Electric Co.
III	Permanence	H. R. Butzloff	A. O. Smith Corp.
IV	Working Properties	N. J. De Lollis	Sandia Corp.
V	Specifications	M. Petronio	Frankford Arsenal
VI	Nomenclature	F. H. Wetzel	Hercules Power Co.
VII	Research	C. B. Hemming	U. S. Plywood
VIII	Electrical Properties	F. Moser	Pittsburgh Plate Glass
IX	Editorial	F. W. Reinhart	Natl. Bureau of Standards
X	Wood Bonding	R. F. Blomquist	U. S. Forest Products Lab.
XI	Metal Bonding	F. H. Bair	Wright-Patterson AFB
XII	Adhesives for Plastics	D. A. George	Natl. Bureau of Standards

Activities under the jurisdiction of Committee D-14 are test methods, definitions, and specifications for end-use adhesives. In the initial phases of its organization, D-14's emphasis was almost exclusively on test methods. Now, for example, it is developing specifications for adhesives designed for applications such as labeling glass bottles or attaching acoustical tile to plaster.

Five new test methods and one specification on adhesives submitted by Committee D-14 were adopted at the last annual meeting of the ASTM.

End Use Application

It was this emphasis on end-use application which led to the recent formation of special subcommittees on wood bonding, metal bonding, and adhesives for plastics. Because of the geographical distribution of industry in the United States, the committees on wood and metal bonding have Eastern and Western Groups.

The first meeting of the Western Group of Subcommittee X, wood bonding, was held September 17, 1958 in Seattle, under the chairmanship of Alan Marra. Mr. Marra is also vice-chairman of Committee D-14 itself.

Subcommittee XI's Western Group met in Los Angeles on November 6, to discuss problems related to metal bonding adhesives. N. J. DeLollis of Sandia Corp. is the temporary chairman of this Group, and Steven Yurenka of Douglas Aircraft Co. is the permanent chairman.

ASTM Committee D-14 on Adhesives is now embarking on the greatest expansion in its history reflecting the enormous development of industrial adhesives in the postwar years. On the horizon are standards for mastic adhesives and adhesives for acoustical tile, methods for measuring the effects of variations in glue-line thickness, the penetration of adhesives, and the tackiness of adhesives as well as atmospheric exposure service tests.

The Committee has other end-use applications in mind which could lead to the formation of other subcommittees if interested groups are available to work under its sponsorship. These applications involve adhesives for pressure-sensitive tapes and adhesives for floor tile.

In all these fields, Committee D-14 seeks to arouse the interest of both producers and consumers. At the recent meeting, a representative of the Federal Housing Administration spoke on the need for test methods in the field of floor tile adhesives. He pointed out that the latter category includes attaching tile to concrete as well as to sub-flooring.

In general, it is the Committee's policy that any group of five or more members be permitted to initiate test methods and specification studies under the sponsorship of D-14. Before being accepted by ASTM, these test methods and specification studies are reviewed at least three times by separate ballots and discussions at the level of subcommittee, the committee and the whole society. Such an organization makes it possible for each subcommittee to participate in the discussion and balloting at both the subcommittee and whole committee levels.

Committee D-14 is one whose meetings are fraught with an intellectual tension and a serious down-to-business activity. Because of its persistent care and intelligent chairmanship, tests, specifications, and definitions involved in the work of D-14 are thoroughly worked out, studied further, extensively debated, and carefully worded—all in conformity with the aims and objectives of the ASTM.

The chairman, J. E. Rutzler, Jr.; the vice-chairman, A. A. Marra; the secretary, John J. Lamb; and the membership secretary, W. W. Sederlund are able men with extremely good qualifications. Their attitudes are reflected in the enthusiasm and seriousness of the members of Committee D-14.

All who are interested in contributing to the committee work are urged to contact J. J. Lamb, Secretary of ASTM Committee D-14, 3753 Lankenau Ave., Philadelphia 31, Penna.

New Borden Facility

Borden Chemical Co., New York, N.Y. has announced the construction of a polyvinyl alcohol plant designed to produce 5 million pounds per year and scheduled to go on stream in October, 1959. The new plant, being erected at a cost of $1½ million, will adjoin the company's present polyvinyl alcohol plant at Leominster, Mass. According to Borden, a new continuous process, developed and engineered by Borden technicians during the last two years, will be employed in the new plant. The new process not only will assure the production of extremely high quality polyvinyl alcohol, but also will be versatile enough to produce all grades and viscosities on a continuous scale, the company stated. The company reports that in addition to the paper industry, which uses polyvinyl alcohol primarily for food packaging and in adhesives used for wet strength bags, boxes, gummed tape and milk containers, a big market also exists in the textile industry.

CMRA Holds Symposium On Adhesives Technology and Markets

A Symposium on Adhesives featured the meeting of the Chemical Market Research Association which was held at the St. Paul Hotel in St. Paul, Minn., on November 12 and 13. The first day of the meeting, which attracted an attendance of over 200 members and guests, was devoted to registration and plant tours, while the heavy work was accomplished on the second. Social activities included luncheons on both meeting days and a reception held on the evening of the first day with the First National Bank of St. Paul acting as host.

The plant tours included visits to the local plants of the Minnesota Mining & Manufacturing Co., the Remington Rand Univac Division of the Sperry Rand Corp., and the St. Paul Ammonia Products Co., Inc., which is located in the well-known Pine Bend Chemical Process Area. The visit to Minnesota Mining, which attracted the greatest number, included both the local plant and the Central Research Laboratories.

The Symposium, conducted under the title of "Adhesives: Technology and Markets," consisted of three papers, presented at the morning session on November 13. The first of these, under the title of "What Are Adhesives?", was presented by R. F. Blomquist of the Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wisconsin.

Wider Applications

In his talk, Mr. Blomquist stated that adhesives are finding more and more application in the production of a wide variety of end products, from attaching labels to cans and bottles to the joining of the parts in primary structures of supersonic jet planes. Adhesive bonding was formerly limited mainly to non-structural applications with only a few adherends, such as paper on wood, where convenience was more important than high-level performance.

Recent developments in raw materials and in formulation techniques are, together with new knowledge of fundamental principles, making possible new adhesive bonding techniques and the design of many new composite articles on sound engineering principles; the adhesive bond becomes an integral part of the structure and is intended to perform satisfactorily over long periods of time, often under severe exterior or other unusual conditions.

At the same time, declared Mr. Blomquist, the ultimate consumer has been conditioned by favorable previous experiences to accept more and more adhesive-bonded products, such as exterior plywood, and even to try his hand more and more in using modern adhesives in hobby and in various home improvement projects.

Bonding Advantages

Modern adhesive bonding has many advantages over mechanical fastenings, including the more uniform distribution of stresses from one material to another bonded to it, smoother surface contours, lighter weight, and fast, economical fabrication. These modern adhesive systems, he said, are based on a wide variety of chemicals that range from the older natural protein and carbohydrate materials to all of the newer synthetic resins and rubbers. Catalysts, hardeners, solvents, extenders, fillers, and modifiers are other important chemicals used in these adhesives—not to mention the variety of chemical treatments for preparing metals and other adherends for adhesive bonding.

Mr. Blomquist then discussed the basic principles behind modern adhesive bonding techniques and reviewed the principal chemical raw materials for adhesives as a background for the discussions of adhesives for current and future end-use applications which followed.

R. E. Smith, vice-president for research and development, H. B. Fuller Co., St. Paul, Minn., presented the next paper, this one entitled "Where and How Adhesives are Used." In his talk, Mr. Smith pointed out that there is scarcely an industry or an article of commerce existing today that isn't dependent upon an adhesive in one or more stages of its operation or use.

Although it is difficult to classify properly adhesive consuming industries in logical categories, he stated, a suitable listing by generalized products would include: (1) Packaging and paper converting; (2) Wood products and wood converting; (3) Metal and plastic converting, and (4) Household or consumer.

Modern adhesive technology, declared Mr. Smith, has kept pace with modern adhesive requirements. Some improvements can be made in methods of applying adhesives, however. The speaker made the point that since industrial adhesives are generally sold to industrial firms and not to the general public, their true value and wide use are not well appreciated or advertised.

Most adhesive manufacturers are formulators and not basic manufacturers of their own chemicals or raw materials. Therefore, they represent excellent markets to those who are more basic. If the average man on the street cannot appreciate what adhesives are doing for him today, chemical manufacturers must surely realize the value of several billion pounds of raw materials which today's adhesives require, he concluded.

The final speaker at the session was D. W. Maher, merchandising manager of the Adhesives, Coatings and Sealers Division of the Minnesota Mining and Manufacturing Co., Detroit, Mich. Mr. Maher chose as his topic, "The Future for Future Adhesives." Mr. Maher first observed that some adhesives which exist today plus some which are still to be developed will be finding many unusual uses in the years that lie ahead. New designs, new materials and improved application techniques all point to the broader use of adhesives.

Various Adhesive Forms

Mr. Maher noted with respect to the forms of adhesives which are available today that there are liquids which are 100 per cent solids; there are liquid adhesives which set when they are deprived of contact with oxygen; and there are materials in film form which, upon the application of heat and pressure, transform themselves into powerful adhesives with thermosetting or thermoplastic properties, depending upon their composition.

The speaker went on to cite certain areas in which adhesives can and will profitably be used in the future. In automobile manufacture,

for example, adhesives will be used in bonding channels in such areas as trunk lids, hood sections, door panels and fire walls. Hinges for all uses might well be adhered. In the marine field many uses present themselves.

Tubular construction is another field ripe for exploitation by the adhesives industry. Home building is another area of likely expanded usage. Furniture is still another product which is turning more and more to the adhesives field. There is a job of education to do, the speaker emphasized, but the future seems bright indeed.

At the conclusion of the panel discussion on "Adhesives: Technology and Markets," members and guests participated in a luncheon with D. H. Thomas (First National Bank of St. Paul) presiding. Harry A. Stuhldreher, assistant to the vice-president, U.S. Steel Corp., Pittsburgh, Penna., was the luncheon speaker. During his days at Notre Dame University, Mr. Stuhldreher was one of the famous "Four Horsemen."

Market Shop Session

Following luncheon the meeting resumed with a session devoted to a "Market Shop," or "The Market Research Behind New Chemical Products." Verne C. Bidlack, Jr. (Archer-Daniels-Midland) presided over this session which included a series of short talks followed by a critique by a panel. The critique panelists included F. Murphy (National Starch Products), H. W. Zabel (Roger Williams Technical & Economic Services), W. L. Machner, Jr. (Allied Chemical), T. Stamataky (Union Carbide) and S. D. Koonce (American Cyanamid).

The session began with remarks from W. H. Bromley, Jr., director of marketing, Shawinigan Resins Corp., Springfield, Mass., who spoke on "Polyvinyl Alcohol—A Case Study." Mr. Bromley pointed out how market research was able to define the nature and the growth potenial of the polyvinyl alcohol market.

The next speaker was J. L. Craig of the Spencer Chemical Co., Kansas City, Mo., who considered the subject "Polyethylene." Mr. Craig related the manner in which his company's venture into the plastics field progressed from the stage of an idea to a functioning business operation.

J. C. Hoopes, manager of field distribution for the Freon Products Division, Organic Chemicals Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., chose as his topic, "Fluorochemicals." He related the manner in which market research built fluorocarbon sales and opened up entire new markets.

A. Jonnard, manager of the Trade Analysis Department, Shell Chemical Corp., New York, N.Y., concluded the talks with an address on "Epoxy Resins." The speaker described the product and offered a brief history of their development and use. He outlined the end products in which they find use and touched upon the competitive situation which exists in the sale of epoxy resins.

The technical portion of the meeting over, members and guests next participated in a banquet which was addressed by Laurence M. Gould, president of Carleton College, Northfield, Minn. President Gould is a noted explorer and geologist and was second in command of Admiral Byrd's Antarctic Expedition.

The local arrangements for the meeting were exceptionally well-handled under the chairmanship of Donald H. Thomas (First National Bank of St. Paul). John L. Rendell (Minnesota Mining) served as temporary treasurer for the affair. The following members were in charge of the activities noted:

Program, Donald A. Beadell (Archer - Daniels - Midland); *Arrangements*, Harry C. Paulus (Minnesota Mining); *Registration*, Stafford L. Hopwood, Jr. (Minnesota Mining); *Publicity*, Hugh A. Hamilton (General Mills); *Plant Tours*, M. H. Baker (M. H. Baker Co.).

Committee members included Verne C. Bidlack, Jr. and Royce G. Freese, both of Archer-Daniels-Midland; George Foster, Richard L. Hansen and Allen E. Reynolds, all of Minnesota Mining, and Ralph B. Scott of the Northern States Power Co.

The three papers which constituted the symposium on "Adhesives: Technology and Markets," because of their inherent interest to the industry, are reprinted in full elsewhere in this issue.

Singleton Elected

J. L. Singleton, vice-president, Industries Group, Allis-Chalmers Manufacturing Co., has been elected president of the National Electrical Manufacturers Association for 1959.

Reinforced Plastics Volume Up 10 Per Cent

The annual market study of the reinforced plastics industry shows record sales of 185,000,000 pounds in 1958 with boats, construction, consumer products, transportation, aircraft and missiles accounting for 76 per cent of the total. This represents a 10 per cent increase over the 168,000,000 pounds reported by the Reinforced Plastics Division of the Society of the Plastics Industry, Inc., in its survey of sales in 1957.

According to the division, in 1959, the industry expects to show a sales gain of close to 15 per cent. Reinforced plastics are being used for a growing number of aircraft and missile parts, like the thrust chamber for the two main engines of the Atlas, pre-load baggage containers for the Boeing 707 and the air conditioning ducting in the Lockheed Electra. These and other applications will begin to have their effect on the total volume of sales during 1959 as both military and commercial work moves from the prototype to the full production stage.

Of the 185,000,000 pounds of reinforced plastics estimated to have been sold during 1958 on the basis of the first nine months' business, resins accounted for 99,000,000 pounds, reinforcement for 62,000,000 pounds and fillers, pigments, activators, etc. for 24,000,000 pounds. While the polyesters are still the dominant resin, the industry survey made evident the growing role of epoxies in aircraft, missiles, tanks, ducts, pipe, electrical panels, tooling and architecture; of phenolic resins in aircraft, missiles and electrical parts; and of the acrylics in sheeting and paneling.

Polyester Resin

American Cyanamid Co., New York, N.Y. has formulated a polyester resin, Laminac 4105, for boat builders and other fabricators using hand lay-up techniques and requiring a rigid, fast curing resin for efficient utilization of their molds, the company announced. Laminac's advantages in hand lay-up production are its good wetting properties; no sagging when used in a vertical lay-up with glass mat or woven roving; fast gel, controllable by varying the quantity of methylethyl ketone peroxide used; and short time between gel and cure to sufficient rigidity for removal from the mold, stated Cyanamid.

National Plastics Show Held in Chicago

More than 25,000 makers, users and marketers of plastic products attended the Eighth National Plastics Exposition held in Chicago's International Amphitheatre, November 17-21. The mammoth exhibition was held in conjunction with the Annual Conference of The Society of the Plastics Industry, Inc. which on November 18th, opened a three-day series of formal sessions at the Morrison Hotel.

At the Amphitheatre, more than 200 individual company displays showed off the achievements of an industry which in the past ten years has grown five times as fast as the total expansion of all U.S. industry. Many of these displays underlined the close ties between the plastics and adhesives industries.

The dramatic manner in which ultra-high-strength adhesives, laminating materials and protective coatings are now solving tough industrial problems provided the theme for the exhibit of Narmco Resins & Coatings Co. Two revolving panels photographically illustrated specific uses of these materials. Of particular interest was a military application of metal-to-metal adhesives in the development of an advance-design rotor blade for the Bell XH-40 helicopter. Laminating sheet stock and extrusions resulted in eliminating extra weight and savings in the cost of expensive forgings. The end product also had superior fatigue resistance.

Other Exhibits

At the display of Catalin Corp. of America, there was some interesting material on the use of the company's industrial resins in wood adhesives and particle board binders. On exhibit were Catalin's wide range of readily blended, fast curing urea, modified urea, resorcinol, phenolic and melamine resins for industrial woodworking and furniture operations.

Among the items featured at the Interchemical Corp.'s display were the IC Laminating Adhesives. The latter are designed for bonding vinyl film and sheeting to itself and to woven or knitted cotton and synthetic fabrics. Formulations are also available for laminating polyethylene film. Company technical representatives were on hand for consultations on specific problems. This service, incidentally, was available at most of the exhibits.

A trip through "space" was offered visitors to the Monsanto Chemical Co. exhibit. The clever display dramatically highlighted the company's comprehensive showing of adhesive materials. These included urea, melamine, phenolic and resorcinal resins under the trade names of Lauxite and Resinox, and casein and soybean Lauxein adhesives. Aspects of the display pointed up the qualities that recommend Lauxite and Resinox as cold-setting adhesives and glues for exterior and interior plywood and furniture. These adhesives are also used in laminating wood arches, beams, edge gluing of lumber and door assembly work.

Plaskon adhesives, a versatile line of urea powder glue, urea liquid glue and hardeners for all types of gluing, including hot and cold pressing, were on display at the exhibit of the Allied Chemical Corp. Examples of typical applications shown went from such products as furniture to boats.

Epoxy resins were highlighted at booth of CIBA Products Corp. CIBA, of course, does not produce formulations of epoxies, but supplies the basic resins to manufacturers and formulators. The display pointed up the high shear and tensile strengths obtainable with adhesives based on Araldite Epoxy Resins. These adhesives are used for bonding metal, plastics, wood, ceramics and concrete.

Eastman Chemical Products, Inc. showed the new Eastman 910 Adhesive and stressed the fact that this high strength adhesive develops strong bonds between virtually any combination of materials without the necessity for heat, pressure, solvent evaporation or long curing time.

The display of the Avery Adhesive Label Corp. indicated the imaginative possibilities of custom-made self-adhesive labels. Equipment of the company includes labelers for the production lines as well as a complete line of label dispensers for manual or electrical operation. Just about everybody at the Exposition went home with one or two gift boxes of self-adhesive airmail labels in a clever two-piece cardboard dispenser box. Examples of industrial uses of pressure-sensitive labels shown included those for product identification, instructions, inventory control, price marking and coding.

The morning symposiums of the SPI's Annual Conference held at the Morrison Hotel threw a great deal of light on the industrial potential of many of the products on display at the Amphitheatre. Topics covered at the sessions included: sheet forming, management, plastics-in building, cellular plastics, plastics in appliances, and the merchandising and distribution of plastic products. A special International Forum surveyed developments in Argentina, England, Germany, Italy, Japan and the U.S.S.R.

Polymeric Plasticizer

Monsanto Chemical Co., St. Louis, Mo., has announced the development of a fast-blending polymeric plasticizer for permanent flexibility in a broad range of general purpose polyvinyl chloride applications. The compound, called Santicizer 409, is described by Monsanto as highly resistant to extraction and migration, low in both odor and color and highly compatible under humid conditions. The company claims that 409's efficiency, electrical resistivity and permanence under heat aging make it an ideal plasticizer for wire coatings and film for electrical tape. According to Monsanto, the permanence, low cost and excellent compatibility of the compound should be of interest to manufacturers of general film sheeting and coated cloth. For manufacturers of adhesive-backed films, it is reported to offer the attractions of low color, processing ease and low migration to the adhesive mass.

Conference Program Set

The Plant Maintenance & Engineering Conference, to be held at the Public Auditorium, Cleveland, Ohio, January 26-29, 1959, will feature speakers from 19 states, the District of Columbia and two Canadian provinces. The conference will take place during the first three days of the Plant Maintenance & Engineering Show. Both events are devoted to the upkeep of the nation's factories, and about 400 companies will demonstrate equipment, services and products. Almost one-third of the conference's topics are new to the program, with ten industries getting special attention. They include nuclear products, abrasive products, metal working and fabricating, assembly plants, chemical, electrical manufacturing, petroleum processing, pulp and paper, foundries, and research and development laboratories. Twenty of the sessions will consider general problems affecting all plants.

Jan. 5-6. Winter Market, American Furniture Mart, Chicago, Ill.

Jan. 5-16. International Home Furnishings Market, Merchandise Mart, Chicago, Ill.

Jan. 12-16. National Housewares Exhibit, Chicago, Ill.

Jan. 26-29. Plant Maintenance and Engineering Conference, Public Auditorium, Cleveland, Ohio.

Jan. 31-Feb. 4. Hobby Industry Association Trade Show and Convention, Hotel Sherman, Chicago, Ill.

Feb. 2-5. National Auto Accessories Exposition, New York City Coliseum, New York, N. Y.

Feb. 3-5. 14th Reinforced Plastics Conference, Edgewater Beach Hotel, Chicago, Ill.

Feb. 23-26. 44th TAPPI Annual Meeting, Commodore Hotel, New York, N. Y.

Mar. 9-14. American Toy Fair, New Yorker and Sheraton-McAlpin Hotels, New York, N. Y.

Mar. 17-19. 15th Annual Conference and Corrosion Show, National Association of Corrosion Engineers, Sherman Hotel, Chicago, Ill.

April 5-10. American Chemical Society, Biltmore Hotel, Boston, Mass.

April 6-8. 8th Annual Meeting of the Building Research Institute, Penn-Sheraton Hotel, Pittsburgh, Penna.

May 17-21. 61st Annual Meeting of the American Ceramic Society, Palmer House, Chicago, Ill.

May 25-27. 10th TAPPI Coating Conference, Statler Hotel, Boston, Mass.

June 9-12. Materials Handling Institute Exposition, Public Auditorium, Cleveland, Ohio.

June 15-19. Annual Meeting of the American Society for Engineering Education, Pittsburgh, Penna.

June 21-26. American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N. J.

July 1-19. Chicago International Fair Exposition, Navy Pier, Chicago.

Aug. 18-21. 10th TAPPI Testing Conference, Multnomah Hotel, Portland, Ore.

Produces Fumaric Acid

Pittsburgh Coke & Chemical Co., Pittsburgh, Penna., has placed a new plant on stream for the production of fumaric acid, thereby becoming one of the three producers of this chemical in the United States. The new facility is expected to increase the availability of the high quality fumaric required by the expanding polyester plastics industry, the company states. Production of fumaric acid by the company was made feasible through the development of new techniques in its Research and Development Department, which utilized integrated materials from Pittsburgh's phthalic anhydride operation. Present national production of fumaric acid is estimated to be 10 million pounds.

Buys Chemical Plant

Union Carbide Corp., New York, N.Y., has exercised its option to purchase from Amoco Chemicals Corp. the utilizable facilities which remain on the 306 acre tract at Brownsville, Texas, site of the processing plant formerly operated by Amoco. The option also includes the 42 mile Welasco-Brownsville natural gas pipeline. Carbide reports that engineering studies will be made for additions and revisions at the site. Utilization of these facilities will be deferred for this reason and also will depend upon completion of satisfactory arrangements for fuel gas and raw material supply, the company stated. Operations at Brownsville will be carried on by Union Carbide Chemicals Co.

Spectrophotofluorometer

American Instrument Co., Inc., Silver Spring, Md., is marketing an instrument called the Aminco-Bowman Spectrophotoflorometer, which can be used to quantitatively assay and identify fluorescent compounds throughout the visible and ultraviolet regions. American Instrument reports that research has extended from the National Institutes of Health, where scientists are identifying and quantitatively assaying serotonin, epinephrine and norepinephrine in human tissue, to the canning industry where the instrument is used to identify toxins produced by bacteria causing botulism. The company claims that the spectrophotofluormeter can be used for such applications as the investigation of enzyme-coenzyme interactions; development and improvement of pesticides and insecticides; studies of organic compounds of pharmacological interest; and cancer studies. Prior to the advent of this instrument, fluorescent measurement was limited to available filters ranging from 365 millimicrons up, and since many compounds are activated and fluoresce at wavelengths below 365 millimicrons, this factor severely limited various types of analysis, the company stated. The spectrophotofluorometer has a range from 200 to 800 millimicrons, the company reports, and it incorporates a Xenon lamp which permits excitation at wavelengths not previously possible, and permits scanning of the activation spectrum, a feature not previously possible with only mercury lamp instruments.

Borden Adhesive Plant

Borden Chemical Co., New York, N.Y. has announced the construction of a new coatings and adhesives manufacturing plant at Illiopolis, Ill. The plant is expected to be in production by July, 1959 and will serve the packaging, building, plastics, coatings and adhesives industries in Chicago, St. Louis, Detroit, Kansas City and other Midwestern cities. According to Borden, the new plant represents an expansion of current operations of its Coating and Adhesive Department at Peabody, Mass., where the department manufactures industrial coatings and finishes, adhesives, plastisols and hot melts; and at Middlessex, N.J., where the department manufactures flooring mastics, underlayment, flooring, asphalt emulsions and other building material products.

Flintkote Acquisitions

Flintkote Co., New York, N.Y., has announced a merger with the Hankins Container Co., Cleveland, Ohio, and the purchase of all assets and business of the Orangeburg Manufacturing Co., Inc., Orangeburg, N.Y. The merger with Hankins will enable Flintkote to establish a nation-wide container business, the company stated, while the Orangeburg pipe producing properties will result in further expansion of the diversified line of building and construction materials already produced by Flintkote. The company reports that its sales of nearly $120 million for 1957 will be increased about $12 million by the Orangeburg acquisition and by another $27 million through the Hankins merger. The two companies will retain their identities as divisions of Flintkote, and W. L. Davis, president of Hankins, and Hugh J. Robertson, president of Orangeburg have been elected to the Flintkote board of directors.

New Armour Plant

The Adhesive Division of Armour & Co., Chicago, Ill., has announced its plans for the construction of a new soluble dried blood plant at St. Paul, Minn. Animal blood collected at Armour meat packing plants will be used to produce an adhesive with a special, water resistant property, for use in the paper, cork, rubber, plywood and mineral flotation fields, the company stated. According to Armour, the plant is designed to be the most modern high temperature, spray dried blood facility in the world, and is scheduled to be in operation by May, 1959 with an estimated capacity of 5 to 7 million pounds of soluble blood a year.

Purchases Half Interest

General Mills, Minneapolis, Minn., has purchased a half interest in the Sidney, Nebr., safflower processing plant of the Pacific Vegetable Oil Corp., San Francisco, Calif. According to the company, safflower seeds are rich in edible oils which show promise for pharmaceutical use, are used in the paint and varnish industry, and have other industrial applications. The company reports that its interest in the Nebraska processing plant will provide General Mills with facilities to begin immediate production of oil and meal.

Portrait Of

John Delmonte

Mr. Delmonte, one of the members of the ADHESIVES AGE Editorial Advisory Board, is the president and owner of Furane Plastics, Inc., Los Angeles, Calif. He earned his B. S. E. E. at New York University in 1933, and received an M. S. degree from Massachusetts Institute of Technology a year later.

After graduation, Mr. Delmonte became an engineer for the Naval Aircraft Factory at Philadelphia, Penna., and then assistant chief engineer for the Sunbeam Electric Co. Previous to the formation of Furane Plastics, he was technical director for the Plastics I. T. Institute in Los Angeles, Calif.

Furane Plastics was organized in 1945. The company has a fifteen-man Research Department and fifty technical sales representatives. Mr. Delmonte, himself, has served the organization in every capacity and now divides his time about equally between the home office in Los Angeles, and trips to manufacturers' representatives throughout the United States.

Mr. Delmonte is also president of Delmonte Plastics and the Delsen Corp., both of which are located near the Furance plant. Delmonte Plastics merchandise materials not manufactured by Furane Plastics and Delsen manufactures electronic and metering equipment used in the plastics industry.

Keenly interested in the technology of plastics, Mr. Delmonte is a prolific writer and has contributed many books and scientific papers to plastics literature.

3M Names Two

Minnesota Mining & Manufacturing Co., St. Paul, Minn., has announced the election of Dr. Carl E. Barnes as vice-president for research, with responsibilities for all major research programs. The company also announced that Dr. John W. Copenhaver has been named director of central research, the post formerly held by Dr. Barnes. Dr. Barnes joined 3M in 1954 as central research director after serving as director of research for Arnold, Hoffman & Co., and as associate director for General Aniline & Film Corp. Dr. Copenhaver was associate director of research for the M. W. Kellogg Co. when the firm was acquired by 3M. Shortly after the acquisition, he became an associate director of 3M's Central Research Department.

Named Tote System Agent

G. N. Johnston Co., Ltd., has been named exclusive Canadian representative for the Tote System of bulk materials handling equipment for Tote System, Inc., Beatrice, Nebr. Johnston will handle the account from its three offices at London and Toronto, Ont., and Montreal, Que. With the new appointment, Tote System is now represented in two Canadian provinces, Hawaii, Puerto Rico and 23 of the American states. Pressoturn, Ltd., is licensed to manufacture the system in England. The company manufactures a complete line of materials handling equipment including the hermetically-sealed Tote Bin; "standard" Bins; Tote Tilts; and Tote Tanks.

Sales Higher

Pittsburgh Coke & Chemical Co., Pittsburgh, Penna., reports that its sales for the third quarter amounted to $11,754,000, slightly higher than those of the two preceding quarters of this year. Third quarter net income after taxes amounted to $272,000 or 14c per common share, as compared with earnings of $233,000 or 11c per common share in the preceding quarter. Sales for the first nine months of 1958 amounted to $33,295,000 with a net income after taxes of $715,000 or 34c per common share. During the same period in 1957, sales amounted to $40,714,000 and a net income after taxes of $2,477,000 or $1.87 per common share.

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Plan Adhesives Session

A full week session on the Chemistry of Adhesion has been scheduled by the Gordon Research Conference and will be held on August 31 to September 4, 1959. Alan A. Marra, of the University of Michigan, will be chairman of the conference, while H. F. Wakefield, Union Carbide Plastics Co., will act as vice-chairman. As an indication of the stature which adhesives research has now attained, last year's conference on adhesives was heavily oversubscribed by chemists, physicists, mathematicians, rheologists and scientists in other areas. Five years ago, however, the first Gordon Research Conference on Adhesion attracted a relatively small number of scientists.

A complete Chemistry of Adhesion program will be available early in 1959. Information regarding registration procedures may be obtained from Dr. W. George Parks, director, Gordon Research Conference, University of Rhode Island, Kingston, R. I. Attendance at each conference is limited to one hundred specialists in the subject field of discussion.

Opens New Offices

Chemicals Division of Eastman Chemical Products, Inc., New York, N. Y., has established new sales offices in Atlanta, Ga., and Greensboro, N. C., for its industrial and specialty chemicals. Located at 3133 Maple Drive, N. E., the new Atlanta office will be headed by Jack T. Mahaffey, who will represent Eastman in Georgia, Florida, Alabama, Mississippi and Tennessee. Richard Fayssoux has been assigned to the Greensboro office, located in the Jefferson Standard Building, where the division presently has offices which handle dye sales under the supervision of R. G. Cooper. Mr. Fayssoux's territory will consist of Virginia, North Carolina and South Carolina. The new territorial assignments are designed to intensify the company's sales activities and provide better service to the expanding chemical industry in the Southeast.

Universal Tester

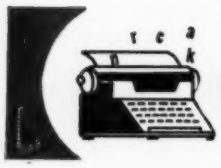
A new multi-low-range universal tester is described in an illustrated six page folder released by W. C. Dillon & Co., Inc., Van Nuys, Calif.

Silicone Anti-Adhesive

A silicone anti-adhesive paper coating, called Syl-off, has been developed by Dow Corning Corp., Midland, Mich. It is reported to give thorough release from kraft, glassine, parchment, multiwall bag liners, boxboard, plastic film and other packaging materials. According to Dow, Syl-off coatings impart excellent release characteristics and water repellency, are permanent, and will not contaminate, migrate or alter stocks or packaged products.

City Sets Trap

A new method of detecting persons who have given false fire alarms has been initiated in the City of New York. The city is conducting an experiment in which an invisible fluorescent tracer paste is painted on fire alarm boxes. The paste sticks to the hand of anyone touching the box and turns up green under the ultraviolet rays of a special portable lamp used by firemen.



names in the news

Mark P. Malkovich has joined the Technical Product Department of Morningstar-Paisley, Inc., New York City, and will be responsible for the development of new products for markets not previously covered by the company.

Walter P. Hwozdek, who joined the research and development staff of National Polychemicals, Inc., in 1954, has been appointed development manager for the company.

Gerard E. Claussen, previously in charge of the Fundamental Research Committee of the Welding Research Council, has joined Arcrods Corp. as director of research and welding engineering.

Herbert Schwartz, formerly associated with American Silver Co. and Duramic Products Co., has been named resident sales engineer in the Metropolitan New York territory for Isochem Resins Corp.

Arthur R. McDermott, formerly associated with Emery Industries, Inc., has been appointed technical sales representative in the Midwest territory for the Activated Carbon Division of the Pittsburgh Coke & Chemical Co.

Daniel J. Goeke, formerly eastern district sales manager for the Larsen Products Corp., has been appointed educational director for the company.

A. X. Hiltgen has been promoted to technical service manager for the Activated Carbon Division of the Pittsburgh Coke & Chemical Co. He formerly served as technical sales representative in the division's Midwest territory.

John W. Touhy, who joined the Wilton Tool Manufacturing Co. as an executive trainee in 1956, has been promoted to the position of assistant sales manager.

Fred E. Huss, a 15-year veteran of the materials handling industry, has been appointed exclusive sales and service representative in Northwestern Ohio by Lewis-Shepard Products, Inc.

Barton T. Bawden, who has been in technical sales work for a number of years, has been appointed West Coast technical sales representative for the Activated Carbon Division of the Pittsburgh Coke & Chemical Co. Headquarters will be located at a newly opened sales office in San Francisco, Calif.

New Reference Manual

A new technical bulletin, "Liquid Polymer/Epoxy Resin Systems," has been published by Thiokol Chemical Corp., Trenton, N.J., to serve as a basic reference manual for plastics compounders. It is reported to provide general information on the increased flexibility, impact and chemical resistance which are obtainable with this system for protective coatings and adhesives, as well as electrical potting, casting and plastic tooling applications. The bulletin describes the proper methods for selecting and compounding liquid polymers with suitable epoxy resins, curing agents and fillers to obtain the desired handling and physical properties from the wide range possible.

Epoxy Based Coating

Araldite epoxy resins, produced by Ciba Products Corp., Kimberton, Penna., are being used by Preco Chemical Corp., Farmingdale, N. Y., as a base in weather resistant coating on concrete block construction. The coating, called Ceramix Glas, is a two part resin hardener combination that cures to a ceramic-like finish at normal temperature, stated Ciba. According to the company, the unique ceramic-cement resin mixture benefits from the oustanding combination of eopxy properties such as low water permeability, good weather resistance, excellent adhesion, salt-spray resistance and the ability to withstand chemicals, solvents and fumes.

ASTM Committee C-19 Announces Test Plan

Committee C-19 on Structural Sandwich Construction of the American Society for Testing Materials has announced plans to sponsor a Symposium on the "Durability and Service Life for Sandwich Construtiion" during the week of October 11, 1959, at the Third Pacific Area National Meeting of the ASTM in San Francisco, Calif. The Committee has also announced that it will participate in the test site program sponsored by the ASTM Advisory Committee on Corrosion and scheduled to begin in April, 1959.

Sandwich Construction Testing

Through participation in this program, Committee C-19 hopes to test the durability and service life of sandwich construction, a comparatively new class of material, which is of vital interest to the aircraft and building construction industries. To be conducted at the ASTM test site at Pennsylvania State University and Kure Beach, N. C., this will be the third exposure program to be undertaken. A report covering the first three year exposure program for the period of April 1955 to April 1958, is being prepared for publication. The second program, still underway, covers the period of 1957 to 1960.

According to C-19, progress continues in the development of test methods to evaluate sandwich constructions. The measurement of creep characteristics and creep rate of sandwich constructions loaded in flexure at any desired temperature is covered in a proposed method to be circulated for letter ballot to the committee. Two proposed methods for determining the resistance to peel of the bond between metal facings and core were reviewed and will also be circulated to the committee for further action. One of these methods involves the use of a 4″ diameter hand or drum peel tester.

West Coast Section?

Committee C-19 is now considering the formation of a West Coast Section as a large number of members and prospective members are located on the West Coast. Members will be solicited to establish the interest and feasibility of such a plan and the question will be discussed at the next meeting of the committee, planned for early Spring 1959, in Dallas, Texas.

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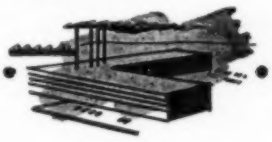

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Pure Research Essential

In an address before the Manufacturing Chemists' Association, L. G. Bliss, president of Foote Mineral Co., Philadelphia, Penna., stated that national defense can no longer rely solely on mass production of weapons since we are engaged in a more subtle and deadly combat in which technical excellence is the determining criterion. He explained that the effective deployment of research dollars and personnel is one of the chemical industry's knottiest problems. Mr. Bliss pointed out that there is the serious problem of pure versus applied research. He explained that universities and research foundations in the past have been the strongholds of pure research; however, today the pressures of industry have forced them more and more into applied, rather than pure, research. The resulting deficiency of pure research may threaten our safety as a nation and the health of the chemical industry, he stated. He went on to deplore the wastefulness of duplication of research effort, explaining that the industry is rapidly approaching a point where it can no longer afford the luxury of duplication. He suggested cooperative sponsorship of pure research programs as a possible solution.

Directory Available

The U.S. Department of Commerce, Washington, D.C., is publishing a periodical, to serve as a central source of information in the United States, on Russian and other technical translations available to science and industry. The periodical, *Technical Translations*, is being published twice a month by the Office of Technical Services, in cooperation with the Special Libraries Association. It lists abstract translated material available from U.S. Government sources, SLA, cooperating foreign governments, educational institutions and private sources. The Special Libraries Association's periodical, *Translation Monthly*, is being incorporated in *Technical Translations*.

Technical Translations is sold by the Office of Technical Services at $12 a year ($4 additional for foreign mailing). A single copy is 60c. Orders should be addressed to Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

Appoints Salem

General Tire & Rubber Co., Akron, Ohio, has announced the appointment of Sam Salem as general manager of the Chemical Division. Mr. Salem succeeds Dr. A. L. Antonio, who is returning to General's rocket propulsion subsidiary, Aerojet-General Corp., Azusa, Calif. Mr. Salem, who has been with General Tire since 1950, has served as vice-president of the A. M. Byers Co., Pittsburgh, Penna., since July, 1957, shortly after General acquired controlling stock interest in that company. He will continue to hold his Byers vice-presidency in addition to heading the Chemical Division. Prior to his Byers assignment, Mr. Salem served as assistant director of manufacturing for General. He also was manager of General's Textile and Adhesive Development Departments, and served in chemical engineering assignments in Portugal and Israel. He is a graduate of Purdue University where he earned both his B.S. and M.S. degrees in chemical engineering.

Irvin R. Spangler has been promoted from assistant sales manager for the Machine and Tools Division of the Michigan Tool Co. to sales manager for the division.

By MELVIN NORD

Self-Destroying Label

U.S. Patent 2,845,728, issued August 5, 1958 to Erwin W. Huber, assigned to Topflight Corp., discloses a pressure-sensitive label which cannot be removed from an article and placed on a different article without damaging or disintegration of the label. It is intended for use in supermarkets to prevent price labels from being switched by customers from one article to another.

As seen in Figures 1, 2 and 3, sheet-like material of any suitable type is used to form a strip (10) upon one surface of which printing (12) is applied to represent any suitable type of marking so as to constitute label (14). The sheet material (10) may be paper, suitable synthetic resin, textile fabric of the woven or unwoven type, metal foil, or the like.

The sheet material also has sufficient strength so that a layer of suitable thickness of pressure sensitive adhesive (16) may be applied to it. This adhesive adheres more firmly to the bottom surface than to the top surface. Thus a coil (22) of a strip arrangement of labels is formed and the outermost end (24) may be pulled from the coil when the coil is mounted in a dispenser (Figure 3) without causing damage to the individual labels.

By using strip material of suitable strength to permit ready uncoiling of the outermost end of a strip of labels from the coil, there is no need to provide a protective or backing strip to the pressure sensitive surface of the labels, thereby saving the expense of such protective strip, as well as eliminating the need to separate the protective strip from the pressure sensitive label prior to applying the label to an article.

The strip of labels may be weakened by a number of different means so as to render them incapable of readily being removed intact from an article to which they have been applied. One such method of weakening is illustrated in Figure 2. This method consists of forming rows of incisions or perforations (32). In the trade, perforations of this type are known as a skip-split. The uncut material of the strip between adjacent ends of the perforated incisions will serve as tie bars (34). Such tie bars prevent the ready separation of adjacent ribbons of the strip on opposite sides of the rows of perforated incisions.

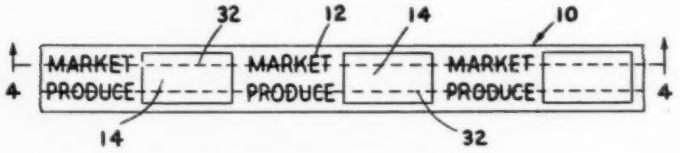


FIG. 1—Label formed of printed sheet-like material with adhesive on back.

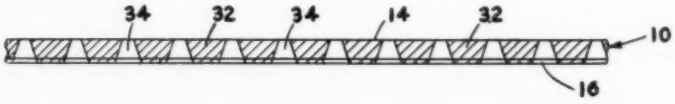


FIG. 2—Side view of label showing incisions which weaken its structure.

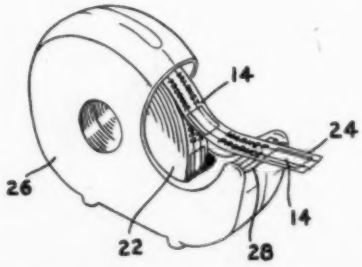


FIG. 3—Coil of labels in a dispenser.

Textile Warp Size

U.S. Patent 2,845,689, issued August 5, 1958 to Adolph Renold and William J. Van Loo, Jr., assigned to American Cyanamid Co., discloses a method of greatly improving textile weaving which also lowers cost in the case of many yarns.

Textile yarns are warp sized with a composition consisting of a non-acidic warp-sizing material (such as gelatin, glue, polyvinyl alcohol, starch, and water-soluble salts of styrene-maleic anhydride copolymers), dicyandiamide, and a reaction product of a monovalent base (such as NaOH or KOH) with an acrylic polymer obtained by polymerizing acrylic acid, acrylonitrile, acrylamide, or a lower alkyl acrylate.

Bonding Elastomers to Textiles

U.S. Patent 2,844,502, issued July 22, 1958 to Homer W. Paxton, assigned to United States Rubber Co., discloses a class of adhesives for bonding elastomers to textile materials such as nylon, rayon or cotton, for use in the manufacture of tires, footwear, and other articles.

The adhesives are manufactured from a mixture of a phenolic resin with an adduct, made at a temperature of 175 to 225°C., of an olefinic elastomer and maleic anhydride. The components are dissolved or dispersed in an organic liquid.

Versatile Adhesive

U.S. Patent 2,846,409, issued August 5, 1958 to Robert J. Herschler, Rainer G. Jaffe, and Francis O. Whipple, assigned to Crown Zellerbach Corp., discloses an adhesive composition made from a benzene-soluble furfuryl alcohol polymer, an aqueous alkali-soluble protein, and spent lignocellulose pulping liquor.

The product is useful as a pigment retainer in cellulosic pulp slurries; as binders for softboards, hardboards, and other composite woody products, and as additives to paper pulp for the improvement of strength properties of the paper.

Sodium Silicate Adhesive

U.S. Patent 2,824,448, issued July 8, 1958 to John E. Dereich, assigned to Diamond Alkali Co., discloses compositions of aqueous adhesive silicate glass which have high adhesiveness to paper surfaces used in laminated paper articles, and lack adhesiveness to heated metal surfaces. Such adhesives are useful in the manufacture of corrugated paperboard and similar laminates.

The solid sodium silicate constituent of the adhesive is present in the range of about 35 to 45%. The ratio of Na_2O to SiO_2 is about 1 to 3.3. To this basic adhesive is added 0.1 to 1% of a modifier consisting of one of the following salts: Copper napthenate, colbalt naphthenate, calcium naphthenate, lead naphthenate, copper resinate, copper carprylate, calcium toluate, copper hexanoate or zinc resinate.

Rubber-Metal Adhesive

U.S. Patent 2,846,492, issued August 5, 1958 to Russell E. Sawyer, assigned to R. T. Vanderbilt Co., Inc., discloses adhesives compositions which are useful in uniting rubber to metallic surfaces. The adhesives contain chlorinated natural rubber, hypochlorinated natural rubber and wax.

Soluble Dextrine Adhesive

U.S. Patent 2,849,327, issued August 26, 1958 to John J. Ryan and Richard A. Weidner, assigned to National Starch Products, Inc., describes a method of making non-lumping dextrines.

The dextrine is moistened by spraying water on it with vigorous agitation until it has a moisture content of 9 to 18%. This moistened dextrine is blended with 7½ to 25% of borax. In addition, there is added a solid hygroscopic or deliquescent chemical, such as ammonium acetate.

As a result of this combination (moisture, borax, and a hygroscopic agent), the resulting dextrine is substantially improved in its solution characteristics. It resembles fine grains of sand, discrete and non-agglomerating. When it is mixed with water, there is no tendency to form lumps. Each grain seems to absorb water and disperse as a separate entity, as contrasted to the tendency of ordinary dextrines to agglomerate into balls or lumps with dry, unwetted cores.

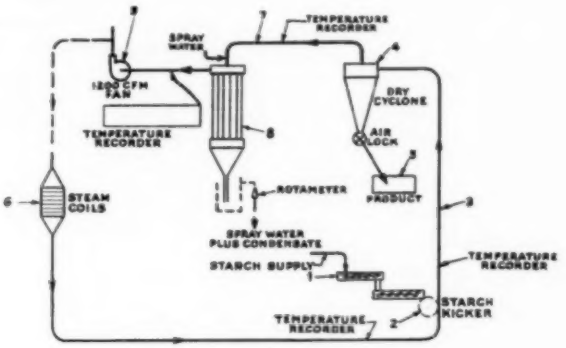
Dustless Starch

U.S. Patent 2,845,367, issued July 29, 1958 to Edward E. Alt, Jr. and Robert J. Davis, assigned to Corn Products Refining Co., describes a new process for gelatinizing and drying starch in a single operation. The product is dustless and is readily suspendable in water.

Starch which has been pregelatinized and is readily redispersible in water would be particularly useful in the paper industry as a beater size. Paper makers prefer to add a starch product to the beater which requires no cooking. Such products would also be useful in clay coating inasmuch as they can be converted with enzymes without passing through the high peak viscosity of ordinary raw starch.

As shown in the diagram, moist starch, e.g., starch cake from a mechanical dewatering operation, is introduced into a feed conveyor (1), from which it is led into a feeding device (2), such as a pin mill machine, which finely divides the starch and forces it into a duct (3) to give hold-up time to the starch and air. After being gelatinized and dried in the duct, the product is collected in a dry cyclone (4), and packed out at a packing device (5).

Air passes through an exit air line (7) to a wet cyclone (8) to adjust the moisture content. Spray water is introduced into the wet cyclone to cool the air to saturation and remove the water. If superheated steam is the drying medium, a portion of the vapor is bled off to the atmosphere. After leaving the cyclone, the air passes through an air recirculating fan (9) and then into an air heater (6) to bring the temperature to the desired level. The dotted line 9 to 6 in the schematic shows that after the air leaves the fan, a cycle has been completed and a new one, as concerns the air, starts at 6. In starting the air cycle, the air may be moistened by introducing steam into the line through a duct (3).



Schematic of starch production process.

Other Patents of Interest

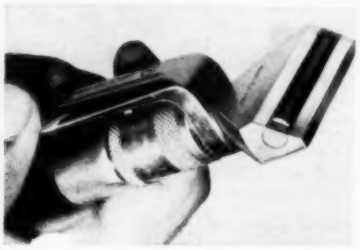
Subject	Inventor or Assignee	Patent No.	Date
Device for dispensing and applying an adhesive tape	Paul Castiglione	2,846,106	8/5/58
Non-dusting modified rosin dry size	American Cyanamid Co.	2,846,328	8/5/58
Glass fibre sizing	Owens-Corning Fiberglas Corp.	2,846,348	8/5/58

Copies of any patents, including those described here, are available from the Commissioned of Patents, Washington 25, D. C., for 25 cents each. Do not send stamps.

new equipment

Glue Guns

A new selection of roller-type glue guns, for use in applying a ribbon coating of glue to any flat surface, features stainless steel construction and non-clogging design. The guns are said to cut gluing costs up to



Roller-type glue gun

67%, minimize operator fatigue, greatly speed the gluing cycle and completely eliminate waste. They are ideal for carton sealing, paper converting and a variety of wood working applications. Available in sizes from ¼ to 4½ inches, these units are said to efficiently handle all low viscosity, cold gluing compounds. *John P. Fox Co., Inc.* **E-33**

Small Batch Blenders

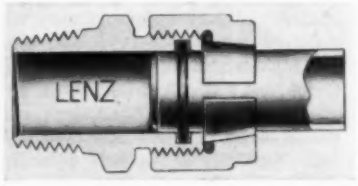
A line of small rotary batch blenders, designed for laboratory or pilot plant use, is composed of machines which are full fledged production equipment. They all feature unit construction with integral motor

Munson small batch blender

drive and controls. A tilting device allows the mixer to be elevated for charging, and a unique disk type discharge gate is said to effectively seal the mixer during the mixing cycle. Discharge is accomplished by operating a quick acting screw on the discharge gate. Models are offered in 5, 10 and 15 cubic foot capacity for material weighing up to 60 pounds per cubic foot. A heavier model is available for material of greater weight. Optional features include quick opening doors in the drum and flush ports for cleaning. *Munson Mill Machinery Co.* **E-34**

O-Ring Tube Fitting

The Lenz O-ring tube fitting, used on vacuum, air and hydraulic systems, seals by means of a standard stock O-ring. A split tapered sleeve holds the tubing in place when the clamping nut is drawn up. Excessive wrench torque is unnecessary because the seal does not depend on the tightness of the nut. The higher the pressure the greater is the grip of



Lenz O-ring tube fitting

the tubing, and the greater the seal of the O-ring. The fittings are available in a full range of shapes—connectors, unions, elbows, tees, crosses and bulkhead connections in outside diameter sizes of from ⅛ to 2 inches. They are available in cadmium plated steel, black phosphate finish or stainless steel. *Lenz Co.* **E-35**

FOR MORE INFORMATION on the new equipment items described here, use the Reader's Service Card elsewhere in this issue.

Moisture Tester

A new moisture determination balance, designated Model No. 6000, is said to measure the moisture content of a wide variety of materials rapidly, simply and accurately. The completely self-con-

Ohaus moisture tester

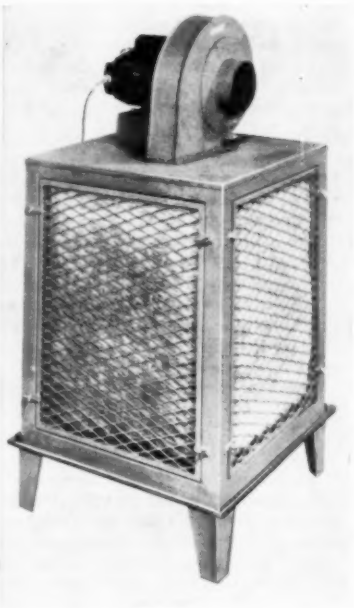
tained unit comprises a magnetically dampened analytical-type chain balance as the weighing system, combined with an infrared heating element which provides even concentrated heat to the sample in a specially designed heating chamber. The instrument can be used with liquids as well as with solid and pulverized materials. Accuracy is said to be within ±1 per cent. *Ohaus Scale Corp.* **E-36**

Laboratory Sifters

The Gyro-Lab sifter is a unit for use in plant, experimental or research laboratories. It is a dust-tight, high speed machine designed for handling all types of free-flowing materials, and is said to duplicate exactly the results to be anticipated from larger machines. The sifter can be mounted on a bench or table or can be furnished with a cabinet complete with time-limit switch, which can be set to automatically stop the sifter at the end of any desired time. The sifters are available in two types and can be clothed with 1 to 400 mesh per lineal inch screens. All sieves have a screening area of one square foot for simplified conversion of test results. The gyration is adjustable from 1½- to 2½-inch circles. The speed is 180 to 300 rpm. Capacity of the sifter depends on the mesh of its screen and nature of the material. *Sprout, Waldron & Co., Inc* **E-37**

Mist Collector

A new mist collector, designated Model MC-412, is especially designed to control mists from wet machining operations that can endanger employee health or create



Torit mist collector

fire and safety hazards. Measuring 22 inches square, it can be floor mounted on legs or placed on a wall or ceiling. It is 47½ inches high, including its top-mounted motor and blower. The collector requires no high voltage electronic equipment, but filters mist by passing the air through high-performance spun glass filters which can be easily and economically replaced. Condensed coolant mist is collected at the bottom of the unit where it can be drained for re-use. *Torit Manufacturing Co.* **E-38**

Humidity-Temperature Unit

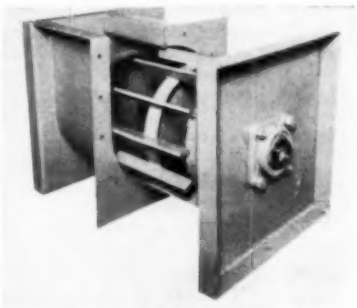
A new indoor-outdoor two-section humidity and temperature recorder with variable limit alarm is said to provide an accuracy of ±3% R.H. over a 15% to 95% R.H. operating range at temperatures from 32° to 130°F. Accuracy is derived from a circular animal membrane humidity sensing diaphragm. The temperature-sensitive element of cantilever type bi-metal is claimed to be accurate within ±1°F. from 0° to 100°F. The alarm range is determined by locating electrical contact blocks on a positioning post in the sensing section. If a recording pen contact touches one of the limit blocks, the alarm circuit is energized until manually reset. Six-inch daily or weekly recording charts are used to contain the data. *Serdex, Inc.* **E-39**

Industrial Thermometer

A new industrial thermometer, known as Model No. 2900, is made of heavy metal, with black figures 7/16-inch high on a white background. Designed with a magnifying red lens tube, it can be easily read from a distance. Total length is 14 inches, and width, 2½ inches. The scale range is from −50° to + 120°F. The thermometer, which weighs ten ounces, has its bulb chamber protected against breakage. *General Scientific Equipment Co.* **E-40**

Rotary Paddle Feeder

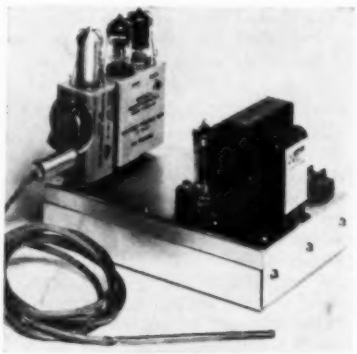
Formulation inaccuracies resulting from pulsating material delivery are said to be eliminated by a newly-designed rotary paddle feeder which delivers a constant, uniform stream. Operating principle of the feeder is based on a series of paddles which revolve around a stable drum within a housing. This design is claimed to prevent pile-up of material and provide a unique self-cleaning feature. Uninterrupted material flow is further assured by a regulating baffle at the discharge point. As material is delivered practically straight-in-line vertically, installation directly below the bin opening, with no loss of floor space, is possible. Capacities handled are up to 30 cubic feet per minute. The standard inlet opening is 8 x 15½ inches, and standard outlet is 12 x 15 inches. Headroom for the unit is 18 inches. Over-all width is 20½ inches. *Richardson Scale Co.* **E-41**



Richardson rotary paddle feeder

Temperature Controller

A new electronic on-off temperature controller offers an optional feature in an anticipating section which is said to provide a close, stable control over temperatures of industrial processes. Also featured are plug-in, epoxy-potted electronic circuits which are dust and moisture proof, and designed so as to be less subject to damage due to vibration. This plug-in circuitry is said to permit rapid in-plant servicing by non-technical personnel. The controller is designed to automatically turn the heat on or off in an industrial process as necessary to maintain the temperature at a desired set point. Temperature differential between on and off is claimed to be less than 1°F. Application tests indicate that temperatures are controlled within 3°F., and to within ±1°F. with the anticipating section, within the temperature range of 200° to 1000°F. The internal relay of the instrument is rated at five amperes, 115 volts. *Electronic Processes Corp. of California.* **E-42**



Temperature controller

Time Sequence Control

A new electronic control instrument is finding use in industrial testing laboratories as well as in production line test points. Completely automatic in operation, the Time Sequence Control, as it is called, may be set to regulate three separate timing operations simultaneously. Operating on three channels, the standard instrument is designed to handle any time up to 130 seconds on the selected channels. Other models with circuitry designed to meet special testing requirements are available. These may be equipped with an automatic reject alarm or a measuring meter relay. *Mid-Eastern Electronics, Inc.* **E-43**

book reviews

Man-Made Fibres. ***By R. W. Moncrieff. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 5½ x 8¾ in. 662 pp. $9.75.***

This book has already had two previous editions under the title, "Artificial Fibres." The new edition follows the outlines of the earlier ones, though the over-all information has been brought up to date and new fibres have been added to the list of those discussed. The author has organized his material into five sections containing 44 chapters. In these sections he has done a scholarly study in depth of the entire synthetic fibers field, covering not only the technical but also the production aspects of his subject.

Included in the discussion of nonwoven fabrics is a brief description of the role of the adhesives used to bind the fibers together. The materials used and methods of fabrication are analyzed in simple non-technical language. The remarkably rapid growth of this industry is one of the phenomena of the current market, and one in which the adhesives manufacturer has more than an academic interest.

A list of literature references follows each chapter, and a bibliography and subject index close the book. Also of interest is an extensive list of the trade names of various man-made fibers, and indication of the type of each, and the name of its producer. All countries which produce synthetics are represented on the list.

Techniques of Plant Maintenance and Engineering—1958. ***Published by Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y. 8¼ x 11¼ in. 212 pp. $10.00***

This volume, ninth in a series, reports the proceedings of the Plant Maintenance & Engineering Conference held in Chicago recently. Included are texts of 35 papers and discussions, and of 450 questions and answers, summaries of nine roundtable discussions, plus 42 relevant charts, tables and illustrations.

Most of the papers and discussions have general application to all industries, including adhesives. Subjects covered, among others, are: "How We Analyzed Our Maintenance Management," "How to Save on Electric Power Bills," "Maintenance in Small Plants (Up to 50 Maintenance Employees)," "Maintenance in Little Plants (Up to 10 Maintenance Employees)," "Fundamentals of Preventative Maintenance," and "Setting and Maintaining Sanitation Objectives." Incidentally, a new addition to the roundtable discussions is one on maintenance of research and developmental laboratories.

Investments by companies in maintenance is estimated to have increased until it now averages $63,662 in plant and equipment per maintenance worker. In consideration of this, much of what this book has to say is worthwhile reading for plant engineers and others involved in factory operations.

Handbook of Chemistry and Physics: 40th Edition. ***Edited by Charles D. Godgman. Published by the Chemical Rubber Publishing Co., 2310 Superior Ave. N.E., Cleveland 14, Ohio. 5 x 7½ in. 3456 pp. $12.00.***

Like its predecessors, the latest edition of this standard work is divided into five basic indexed sections: Mathematical Tables, Properties and Physical Constants, General Chemical Tables, Heat and Hygrometry, and Quantities and Units. More than 100 pages of new and revised scientific facts have been added, with important new information included on such subjects as the thermodynamic properties of both the elements and the oxides, chelating agents, ion exchange resins, superconducting transition temperatures, and the physical constants of inorganic hydrides. Over 200 authorities have collaborated in preparing this new volume, which maintains its continuing reputation for comprehensive presentation of factual data with accuracy and clarity.

Creative Thinking. ***By Charles S. Whiting. Published by Reinhold Publishing Corp., 430 Park Avenue, New York 22, N. Y. 5 x 7½ in. 168 pp. $3.95.***

This short volume concerns itself with operational techniques of creative thinking—group discussion methods such as brainstorming and analytical or mechanical techniques that various persons or groups have found useful in stimulating themselves to produce new ideas. Case histories of programs successfully realized by different organizations are presented. Finally, suggestions for putting across new ideas are included. Interesting reading in consideration of the need for the most efficient utilization of engineers and other creative people in industry today.

Trade Literature

Dehumidifiers. An 8-page standards publication gives NEMA standards for self-contained electrically-operated mechanically-refrigerated dehumidifiers. The publication covers definitions, test instruments, test conditions and procedure, and gives a uniform method for testing, rating and designating the performance of such dehumidifiers. It is availabe for 20 cents. *National Electrical Manufacturers Association.* L-30

Industrial Control. An 8-page descriptive bulletin illustrates a line of industrial control products. Both individual units and assembled controllers are shown. The bulletin also introduces a new line of speed-responsive switches. The function of each piece of equipment is explained, and relevant data on operation given. *Euclid Electric & Manufacturing Co.* L-31

Honeycomb Structure Adhesives. A new 20-page technical bulletin gives engineering data on adhesives for honeycomb structures. Test procedures and results of testing new resin-type and elastomeric adhesives used for bonding aluminum to kraft paper honeycomb core are presented. Adhesive application procedures are described in detail. *Minnesota Mining and Manufacturing Co.* L-32

Adhesives Specifications. United States Government Specifications for a wide variety of adhesives, coatings and sealers are listed in a new 23-page catalog. Military, Army and Federal specifications and their definitions are arranged in numerical order. Brief explanatory data for each are also given. Adhesives which are manufactured by the publisher and which meet the requirements of each specification are listed with each. The binding is looseleaf, so that additions and deletions can be made. *Minnesota Mining and Manufacturing Co.* L-33

Spray Drying System. A new brochure describes advantages of the Nerco-Niro spray drying system and outlines the engineering services offered by its manufacturer. Illustrated and described are portable, utility, pilot and industrial spray dryers as well as the extensive research and custom drying facilities maintained by the company. Text, schematic diagrams and photographs are used to tell a complete story on size, function and operation of the units. *Nichols Engineering & Research Corp.* L-34

Trade Literature

Tape Dispensers. A complete line of automatic and manual tape dispensers and moisteners is described and illustrated in a 4-page brochure. Details of construction, operation and kinds and sizes of tape handled by each are given. Photographs and schematic diagrams are used to portray the various items. *Seal-O-Matic Dispenser Corp.* L-35

Adhesives Line. The line of Epibond adhesives and pastes is described in a 4-page brochure. These include products for use with wood, metal, concrete, glass, clay, ceramics and plastics. A glossary lists 22 of the adhesive products, with brief information on color, physical properties and uses. Packaging data are also included. *Furane Plastics, Inc.* L-36

Insulation Adhesives. A new 4-page illustrated catalog describes adhesives for bonding insulation and insulating sealers for the heating, ventilating, building, automotive, truck, trailer and railroad industries. Four typical insulation adhesives are described in chart form with the uses, temperature limits, application methods, bonding range, solvent, color and estimated coverage area per gallon on each detailed. *Minnesota Mining and Manufacturing Co.* L-37

Folding Carton Magazine. A monthly digest on folding cartons, published as an association paper, presents articles on state of the industry, survey results, evaluating package effectiveness and related subjects. Measuring 5¼ x 7½ inches, the little magazine offers well written and edited articles of interest. Illustrations are used to advantage. *The Folding Paper Box Association of America.* L-38

Web Process Engineering. A handsome 128-page general catalog is devoted to web process engineering. Mechanical and auxiliary equipment required in a completely modern web processing line is described and illustrated. Other subjects covered include the Waldron experimental laboratory. The broad scope of service offered by the manufacturer to customers using web processing operations is described. *John Waldron Corp.* L-39

Instrumentation Application. An 8-page tabloid-type publication is devoted to a round-up of instrumentation applications in the far western states. These include system engineered controls, automatic pH control, data recording systems, feeder temperature control, reactor control and others. The extensive descriptive material is clearly written, and details specifications of exactly what the various installations do, and their production advantages. *Leeds & Northrup Co.* L-40

Ceramic Tile Adhesive. A new water-dispersed adhesive, designated by the manufacturer at CTA-50, for installation of ceramic wall tile, is described in a recently published 4-page brochure. Performance data and properties are given, and a recommended method for applying the adhesive is shown by photographs. One page details advantages achieved in using the new product; these include comfort, ease and safety, according to the manufacturer. *Minnesota Mining and Manufacturing Co.* L-41

Structural Sealing Sealants. Elastomeric sealants for all types of building applications are described in a brochure which features in particular case histories on curtain wall installations where the sealants have been used as superbonding mediums for building materials in use today. Proper handling, mixing, color availability and methods of application are demonstrated. Data on various tests, including adhesion and stress, sag, low temperature, weather resistance and peel strength, are given. *Thiokol Chemical Corp.* L-42

Hydraulic Jet Cleaners. A new 8-page bulletin describes a complete line of modern cleaning equipment. Hydraulic jet models, both portable and stationary, for cleaning of heavy-duty walls, floors and process equipment of all types is described. Also presented is information on equipment for cleaning of tanks, tank cars and tank trucks. Drawings and photographs, as well as essential specifications of each model, are included. *Sellers Injector Corp.* L-43

Masonry Sealer. A new heavy duty masonry sealer made by combining pure rubber latex with a chemically setting adhesive is described in a 4-page brochure. Called Pioneer Hydrocure, the sealer is said to protect against water where conventional waterproofing compounds fail. Mixing, application and painting directions are given. Photographs are used to show application of the sealant, and results in a successful waterproofing installation. *Pioneer Latex & Chemical Co.* L-44

Materials Handling. A new case history bulletin describes how a large manufacturer increased production and shipping schedules without expanding plant facilities by use of fork trucks for materials handling. The 4-page, fully-illustrated presentation gives the complete story of the advantages achieved with the new handling techniques. *Lewis-Shepard Products, Inc.* L-45

Adhesive Resins. A 30-page booklet is divided into two sections, one of which is devoted to resins for use in adhesives. Discussed are types of resins, their advantages and uses; compounding techniques; formulating; compounding with various rubbers, and other subjects. Two pages are devoted to an application chart listing base rubbers from which adhesives are made, type adhesive (oil resistant or oil soluble), suggested resins, compounding methods and typical industrial uses. Eleven resins—phenolic, terpene phenolic and polyterpene—are described in detail, their physical properties, handling characteristics and commercial applications being given. The booklet is well designed, and the presentation enhanced by the use of photographs. *Schenectady Varnish Co., Inc.* L-46

Automatic Weight Control. How to achieve complete automation in continuous or batch processing operations is described in a 6-page bulletin. Text explains how the Select-O-Weigh remote control panel provides a system of electrical controls that directly operate feeders, scales, conveyors, buckets or any other equipment used in proportioning, blending and mixing various materials. A punched card reader control system for fully automatic proportioning and mixing is also described. Eight accessories are illustrated and discussed. *Richardson Scale Co.* L-47

Palletized Materials Handling. A case history bulletin describes and illustrates how warehouse space was increased 20% and the working force operating the installation decreased by 33% through the use of palletized handling of multi-sized cartons and kegs. Nine photos show the step-by-step procedure followed, and complete specifications of pallet sizes, stacking heights, and equipment necessary to use the pallets are detailed. *Lewis-Shepard Products, Inc.* L-48

FOR MORE INFORMATION on the trade literature reviewed here, use the Reader's Service Card elsewhere in this issue.

3M Show Exhibit

The Adhesives and Coatings Division of the Minnesota Mining and Manufacturing Co., Detroit, Mich., has announced that it will present actual installations showing typical uses of a wide variety of new adhesives and sealers for home building application at the National Association of Home Builders Exposition at the Coliseum in Chicago, Ill., from January 18-22, 1959. The company reports that two of the highlights of the 3M display will be new ceramic tile adhesives, designated as CTA-50 and CTA-20, and a new series of polysulphide rubber base sealers, designated Weatherban Brand Building sealers. Other products to be shown in actual installation include: vinyl and rubber floor tile adhesives, carpet tack strip adhesives, contact bond adhesives, sink and counter top adhesives, and adhesives for attaching all types of insulation.

Officers Elected

At the annual meeting of the Gummed Industries Association, Inc., R. T. Meyer, president of Tape, Inc., Green Bay, Wisc., was unanimously re-elected to his second term as president of the association. S. E. Thompson, vice-president, Central Paper Co., Menash, Wisc., was chosen vice-president. Philip O. Deitsh, in his twenty-second year of service with the association, was re-elected managing director. In addition, the following were elected to the board of directors: A. W. Aron (Hudson Pulp & Paper); E. F. Herrlinger, II (Gummed Products); Henry W. Stark, Jr. (Rexford Paper); A. J. Thiel (Ludlow Papers); W. G. Bretson (Mid-States Gummed Paper); J. A. Shartle (Brown-Ridge Mills); and William L. Shattuck (Ahesives Products).

Morningstar Earnings Up

Morningstar-Paisley Inc., New York, N.Y., producer of starches, gums, dextrines, adhesives and specialty chemicals for a wide number of industries, reports that its net profit for the nine-month period ended September 30, 1958, increased by 12 per cent over the same period of 1957. Net profit for the 1958 period amounted to $422,909, as compared to the figure of $377,811 for the 1957 period. Net earnings equaled 85¢ per share, compared with 76¢ per share for the same period of 1957.

Indopol Polybutene

Amoco Chemicals Corps., Chicago, Ill., has announced the addition to their line of a new Indopol polybutene with unusually high viscosity. This line now includes 10 products with viscosities ranging from 40 SSU at 210°F. to the new Indopol H-1900, reported to have a viscosity of about 20,000 SSU at 210°F. According to Amoco, electrical cable oil and specialty sealants for refrigerator and automotive use are among the applications for which the new high viscosity product was developed. Other applications for which Indopol H-1900 may be used include use in adhesives and pressure sensitive tapes, as a thickening agent and as a capacitor insulation impregnant. The company reports that it may also be used in lubricants to improve shear stability and as a viscosity index improver. According to Amoco, Indopol H-1900 is nondrying, light in color and stable to sunlight, moisture resistant and thermally decomposes without residue at temperatures above 650°F. It also exhibits excellent electrical properties.

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